GP-1059
REVISION A

ENVIRONMENT AND TEST SPECIFICATION LEVELS GROUND SUPPORT EQUIPMENT FOR SPACE SHUTTLE SYSTEM LAUNCH COMPLEX 39

ACOUSTIC AND VIBRATION

VOLUME I OF II

(NASA-TM-X-74244) ENVIRONMENT AND TEST SPECIFICATION LEVELS GROUND SUPPORT EQUIPMENT FOR SPACE SHUTTLE SYSTEM LAUNCH COMPLEX 39. VOLUME 1: ACOUSTIC AND VIBRATION (NASA) 306 p

N76-78461

Unclas
00/98 03484

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This revision supersedes all previous editions of this document.

September 15, 1976

DESIGN ENGINEERING DIRECTORATE

LIST OF EFFECTIVE PAGES

The total number of pages in this document is 316 consisting of:

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ABSTRACT

This document presents the predicted acoustic and vibration environments induced by the launch of the Space Shuttle vehicle from Launch Complex 39, Kennedy Space Center, Florida. These environments apply to regions at the launch pad; specifically on the Mobile Launcher Platform, and on and around the Shuttle Service and Access Facility, which includes the Shuttle Service and Access Tower and the Payload Changeout Room. The document provides acoustic and vibration design and test criteria for the facilities, ground support equipment, and equipment installations. Further, it establishes test specification levels for the acceptance and qualification testing of the preceding equipment/facilities.

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SECTION I

INTRODUCTION

1.1 PURPOSE

This document presents the predicted acoustic and vibration environments that will be created by the Space Shuttle launches. It provides acoustic and vibration criteria for the design, acceptance, and qualification testing of the facilities, ground support equipment, and equipment installations. These data are required to support the launch of the Space Shuttle from Kennedy Space Center, Launch Complex (LC) 39.

Volume I contains the predicted acoustic and vibration environments and test specification levels anticipated due to the launch of the Shuttle.

Volume II will contain the predicted thermal and pressure environments and test specification levels expected during the Shuttle launches.

1.2 SCOPE

This document provides an analytical prediction of the Space Shuttle system launch-induced environments based on scaling of the data recorded during Saturn V/Apollo launches.[1] The material in this document will be revised to reflect changes in the facilities configuration and to include pertinent test data as they become available.

1.3 AUTHORITY

This document was prepared by the Planning Research Corporation, Systems Services Company (PRC/SSc)under contract NAS 10-8525 for the NASA-KSC Directorate of Design Engineering, which is the originating agency. The PRC technical lead for this analysis was Mr. Valentin Sepcenko, Principal Engineer, Project and Technical Staff.

1.4 DOCUMENTATION

For information, corrections, or additions to this document contact Mr. Rocco A. Sannicandro, Design Engineering (DD-SED-32), Kennedy Space Center, Florida 32899. Additional copies are available from AD-CSO-2FW, Kennedy Space Center, Florida 32899. Deviations from these specifications may be obtained only from the originating agency, which will provide assistance in the proper use of the specifications.

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[1] Superior numbers in the text refer to items in the Bibliography (Appendix E).

1.5 ABBREVIATIONS AND SYMBOLS

C.L.	confidence level
cm	centimeter
dB	decibel
Δ	designates increment
E(xx)	exponential (10^{xx})
f	frequency
Δf	frequency increment, bandwidth
F-1	Saturn V main engine
ft	foot
ft/sec	foot per second
ft-lb/sec	foot-pound per second
g	acceleration of gravity
g^2/Hz	unit of power spectral density in units of acceleration of gravity squared
g_{rms}	root mean square acceleration in units of acceleration of gravity
GSE	ground support equipment
Hz	Hertz (cycles per second)
KSC	Kennedy Space Center
LC	Launch Complex
LUT	Launch Umbilical Tower
lb	pound
lb-sec/ft	pound-second per foot
MLP	Mobile Launcher Platform
NASA	National Aeronautics and Space Administration
OASPL	overall sound pressure level
OAPWL	overall power level
OBSPL	octave band sound pressure level
oct	octave
PCR	Payload Changeout Room
PRC-SSc	Planning Research Corporation - System Services Company
PSD	power spectral density
ΔPSD	increment of power spectral density used to define superimposed narrow band PSD
psi	pound per square inch
psi^2/Hz	pound per square inch squared per Hertz
rms	root mean square
SPL	sound pressure level
SRB	Solid Rocket Booster
SSAF	Shuttle Service and Access Facility
SSAT	Shuttle Service and Access Tower
SSME	Space Shuttle Main Engine (Orbiter Engine)

SECTION II

TERMINOLOGY AND FORMAT

2.1 GENERAL

A launch-induced acoustic environment represents a dynamic load on the exposed facilities and ground support equipment (GSE) in the form of random pressures fluctuating around the ambient atmospheric pressure. In response to these fluctuating pressures, structural vibrations are generated and transmitted throughout the structure and to the equipment items supported by the structure. Certain equipment items are also excited by the direct acoustic input as well as by the vibration transmitted through the supporting structure.

This document presents the predicted acoustic and vibration environments induced by the launch of the Space Shuttle vehicle from LC-39. This document also provides criteria needed for the design of the GSE facilities, GSE components, and component installations, and provides specifications for the acceptance and qualification testing of GSE components and their mounts. Pertinent acoustic and vibration environment information presented in Appendices A and B defines specification parameters.

The predicted acoustic environment depicted in this douument was calculated by scaling the statistically processed measured data available from Saturn V launches to the anticipated environment of the Space Shuttle. The scaling was accomplished by using the Space Shuttle Main Engine (SSME) and Solid Rocket Booster (SRB) engine parameters given in table 2-1. Drivation of vibration environment for the Mobile Launcher Platform (MLP) and Shuttle Service and Access Facility (SSAF) was accomplished by scaling the Saturn V vibration environment. A more detailed description of the approach taken is presented in Appendix C.

Appendices A and B provide only the test levels. Testing methods, operational mode of test items, and the duration of each test shall be established in accordance with Appendix D.

This document does not provide all the information necessary for the acoustic and vibration acceptance and qualification testing of each individual GSE component. Special cases involving unusually heavy items, in excess of those used on the Saturn V/Apollo Program at similar locations, and components mounted within the acoustically sensitive enclosures may require a deviation from the levels specified herein. Cases involving equipment items previously tested at different levels or by different test procedures will require special consideration for their acceptance if the qualification testing is to be omitted. Deviations from levels specified herein may be obtained only from the originating agency, which will also provide assistance in the proper use of the specifications.

Table 2-1. Rocket Engine Parameters

Parameter	Symbol	Saturn V	Space Shuttle	
		F-1	SRB	SSME
Number of Engines	N	5	2	3
Nozzle Exit Diameter, Inches	D	139.8	141.7	92.0
Exhaust Velocity at Sea Level, ft/sec	V	8550.0	6440.0	9730.0
Exhaust Velocity in Vacuum, ft/sec	V_v	10500.0	7900.0	11940.0
Exit Mach Number	M	3.7	3.0	4.0
Supersonic Core Length, ft $L = 3.45D\,(1+0.38M)^2$	L	233.0	187.0	168.0
Engine Thrust, lbs/engine	F	1.522 E06	2.575 E06	4.173 E05
Exhaust Power at Sea Level Per Engine, W = FV, ft-lb/sec	W	1.302 E10	1.658 E10	4.06 E09
Total Generated Power at Lift-Off, ft-lb/sec	W_T	6.51 E10	3.317 E10	1.218 E10

2.2 CONFIGURATION AND COORDINATE SYSTEM

Figures 2-1 and 2-2 show the launch facilities, MLP, Shuttle Service and Access Tower (SSAT), and Payload Changeout Room (PCR) in prelaunch and launch configurations.

Coordinate system X,Y,Z in figure 2-2 is used to define directions for vibration specifications on the MLP and SSAT. Locations on and within the MLP and on the SSAT are referred to as decks 0, A, and B for the MLP, and as levels 75 through 295 for the SSAT, in accordance with the designations used on structural drawings. The coordinate system X'Y'Z' in figure 2-2 is used to define directions for vibration specifications on the PCR structure.

Figures 2-3, 2-4, and 2-5 show the MLP plan at deck 0 and the identification of the interior compartments at decks A and B used in the definition of acoustic and vibration specifications.

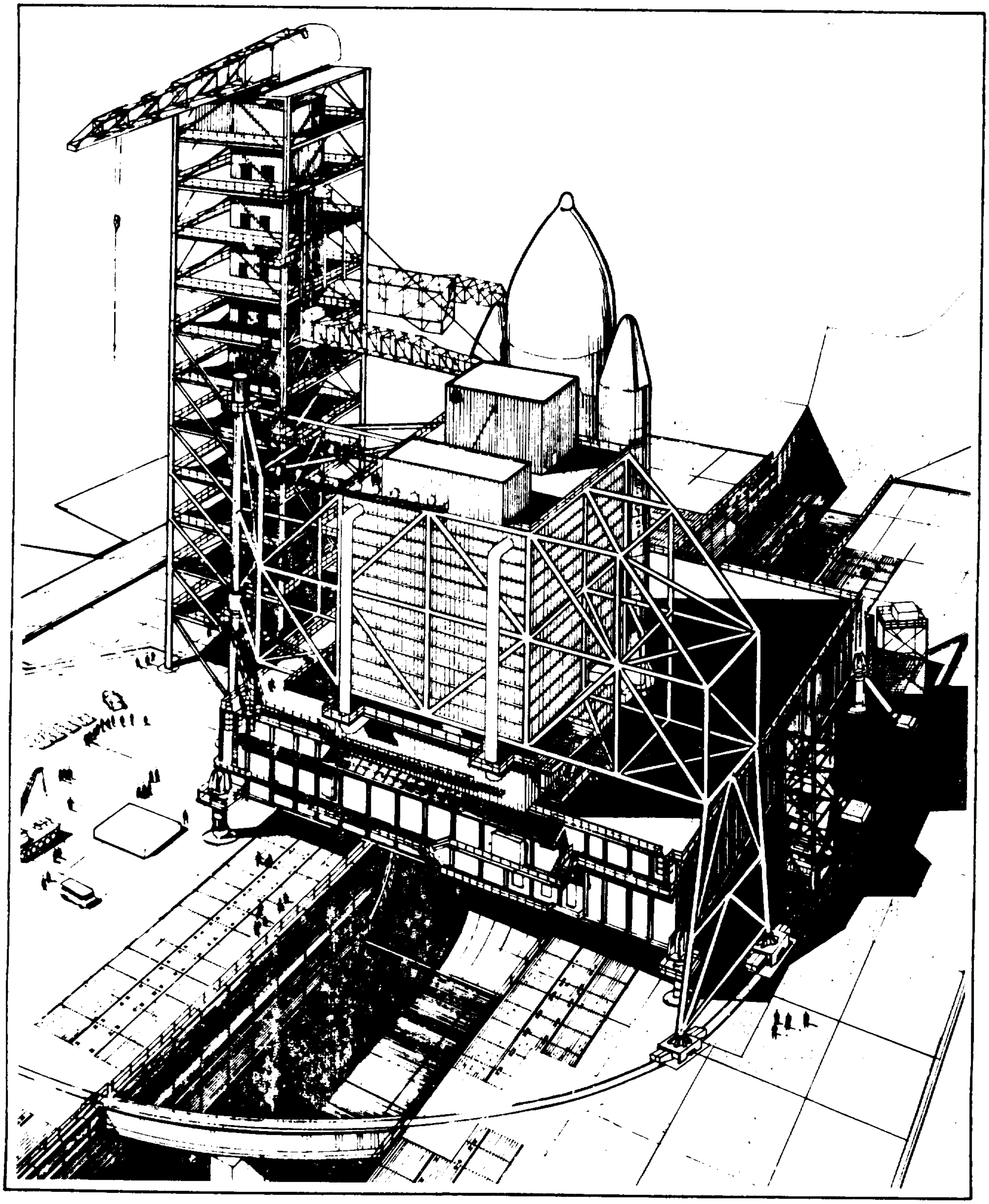


Figure 2-1. Overall View of MLP, SSAT, and PCR at Launch Pad (Prelaunch Configuration)

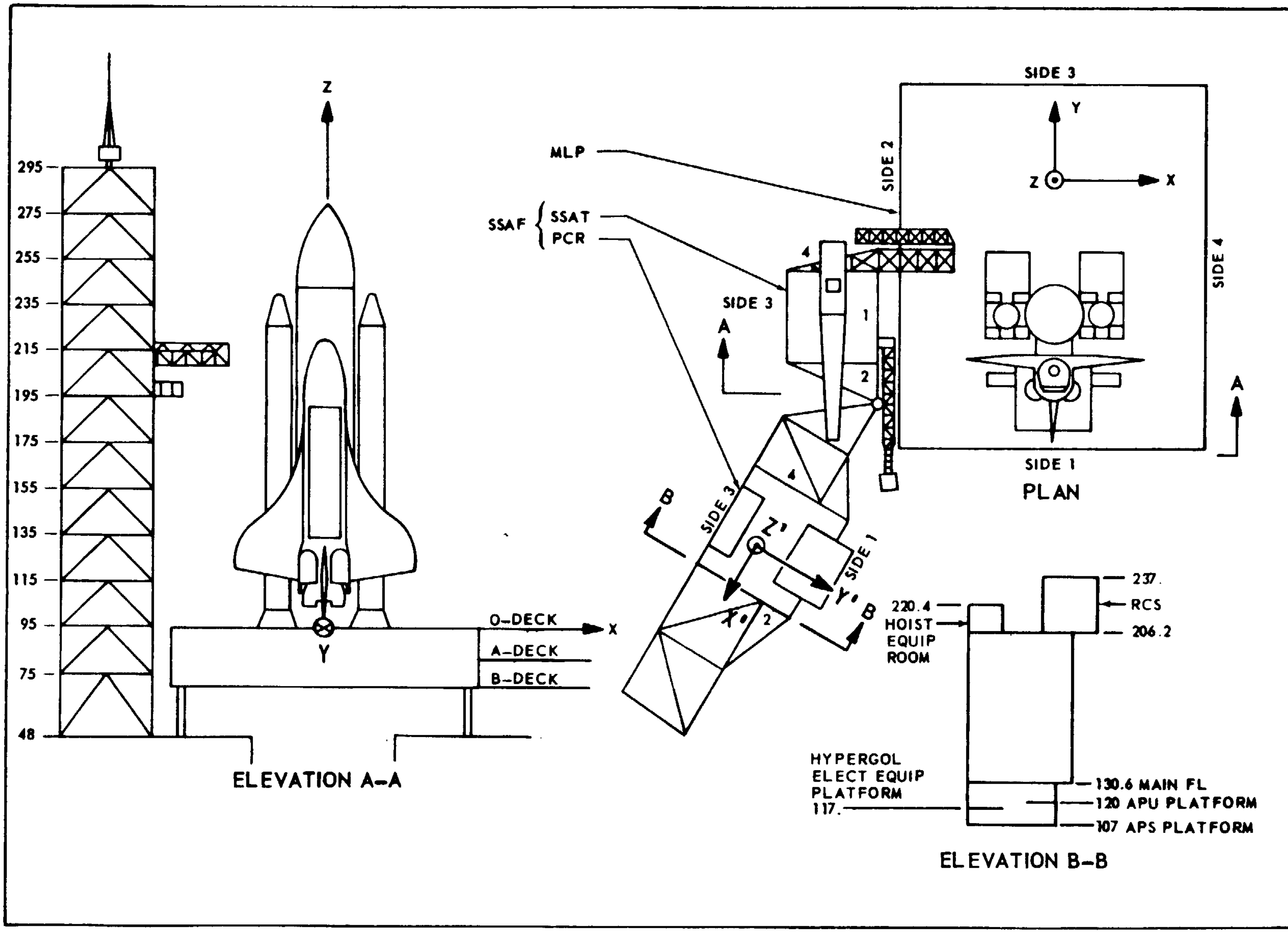


Figure 2-2. MLP, SSAT, and PCR Coordinate System and Reference Levels (Launch Configuration)

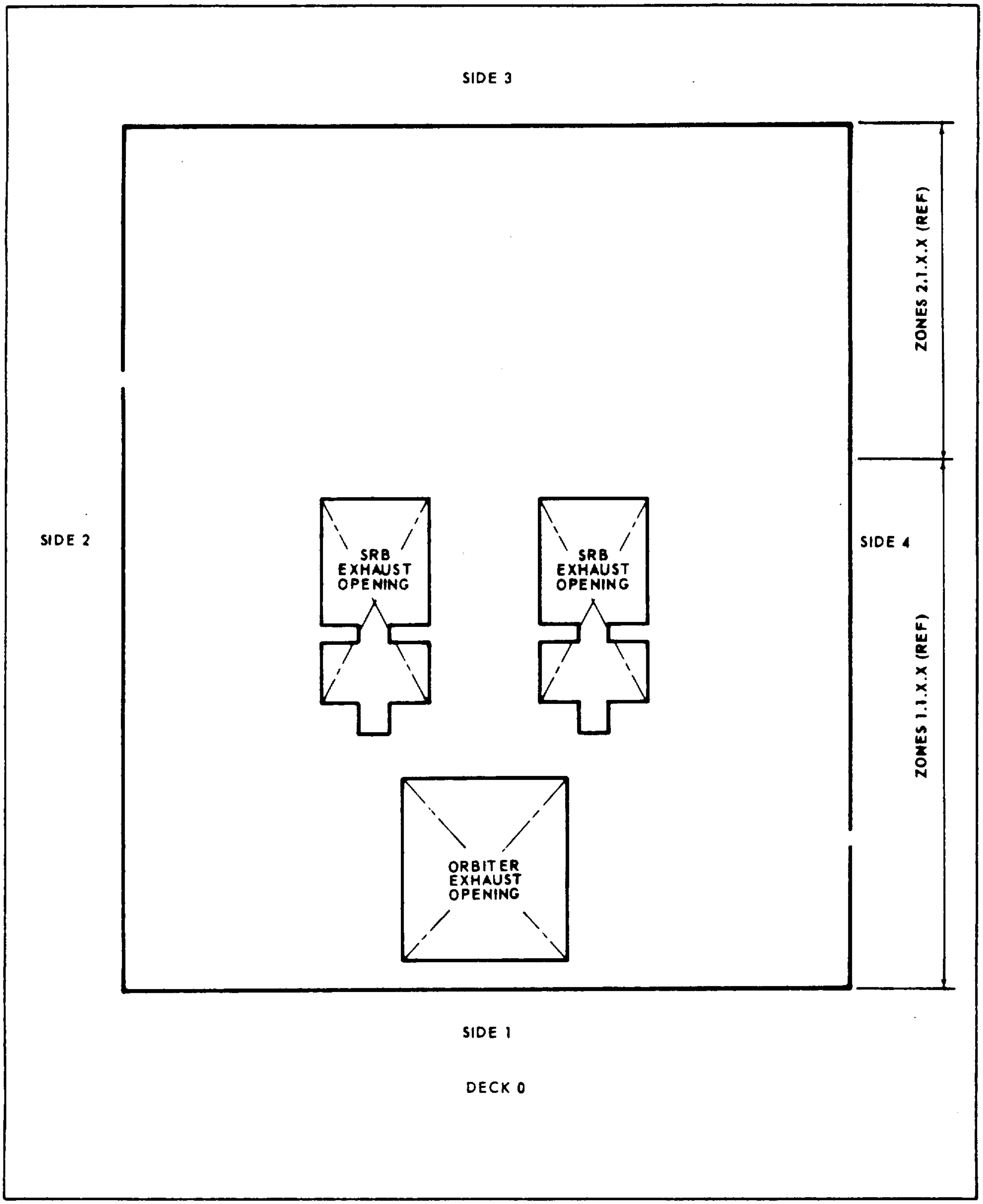


Figure 2-3. MLP Plan

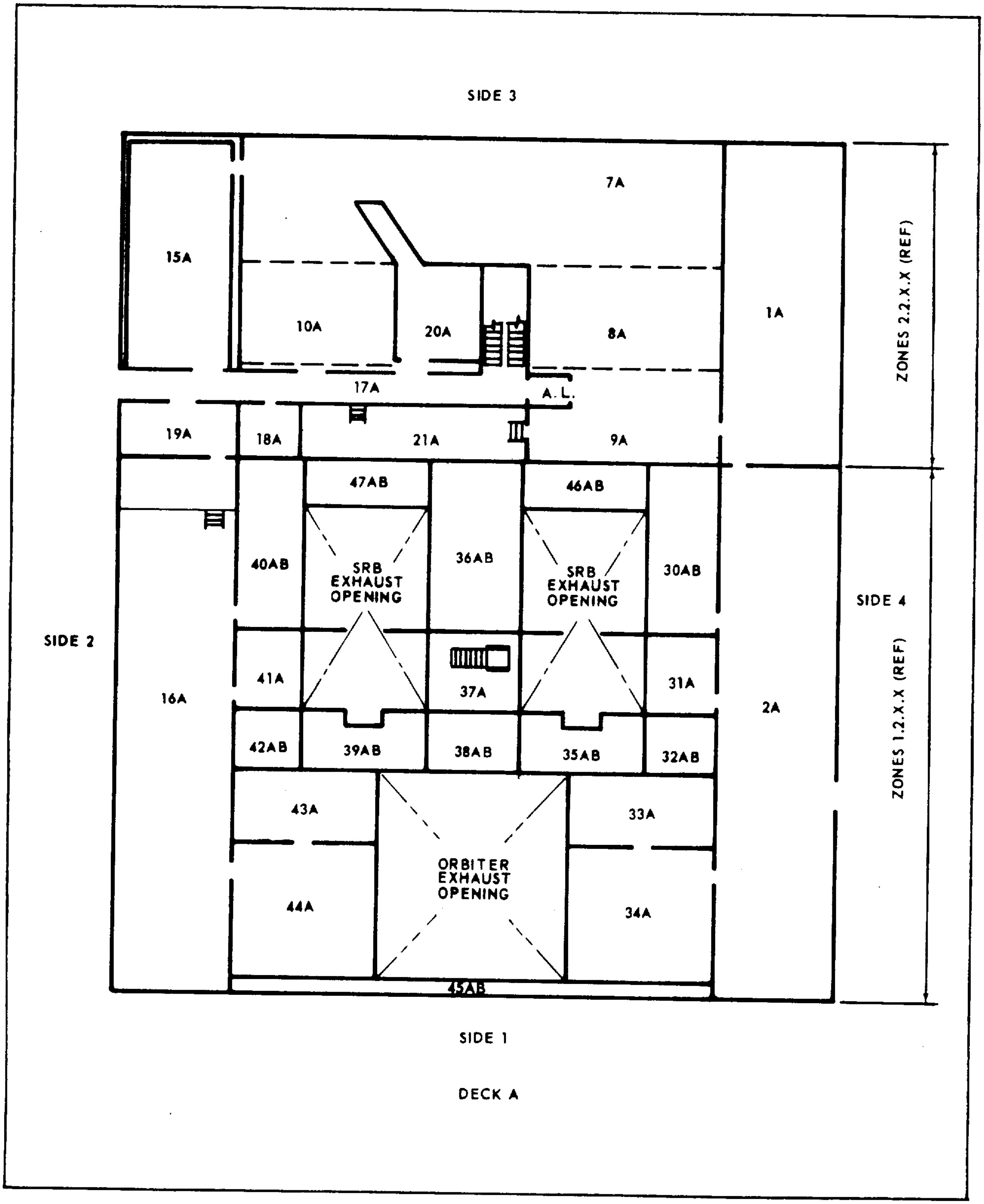


Figure 2-4. Upper Level Compartment Identification for the Interior of MLP

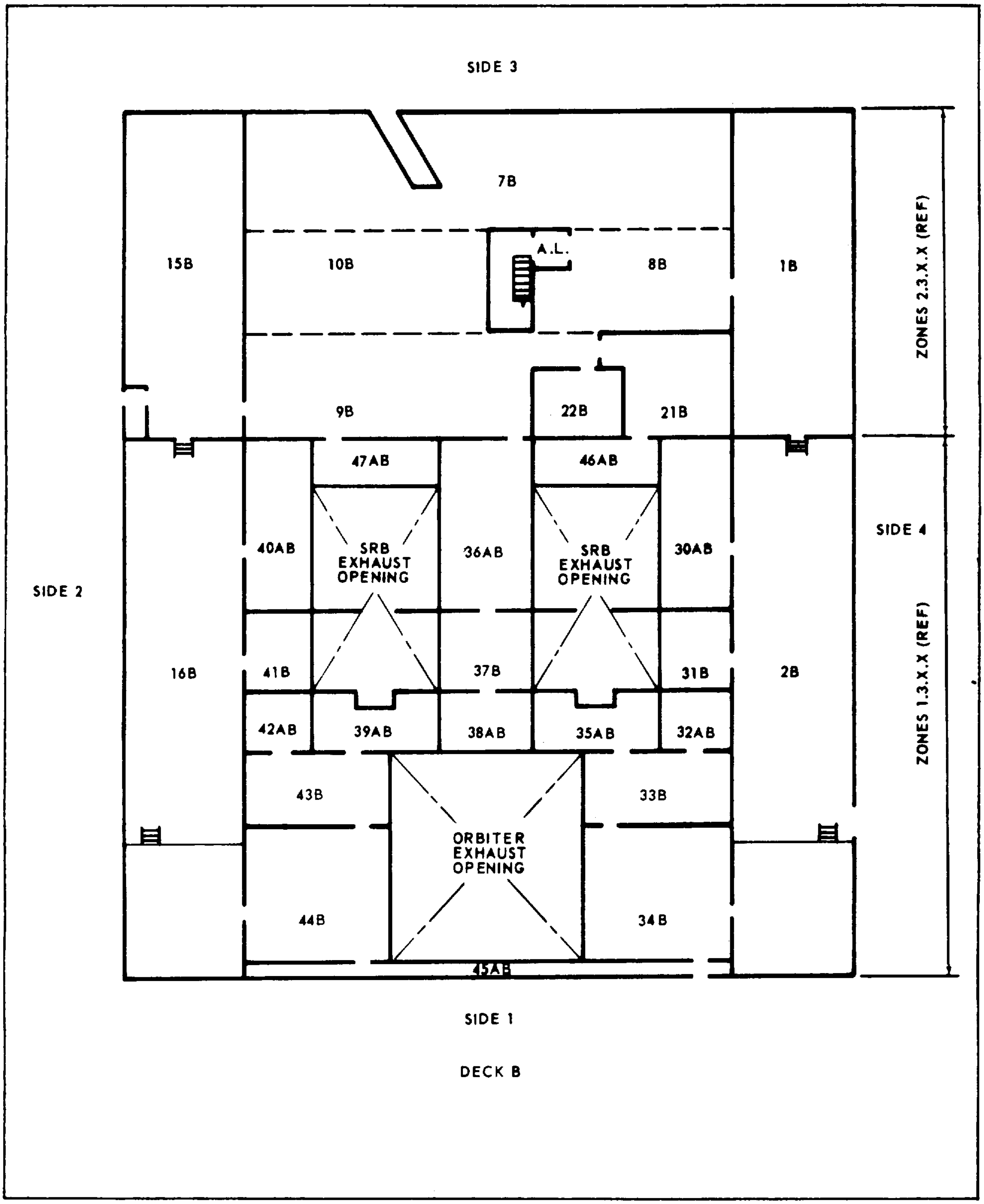


Figure 2-5. Lower Level Compartment Identification for the Interior of MLP

2.3 ZONING

To ensure accurate definition of the Shuttle system environment at specific areas, it is necessary to divide the MLP, SSAT, and PCR into zones. To maintain continuity of zoning and to effectively apply data obtained during the Saturn/Apollo Program, the zoning method depicted and utilized in SP-4-38-(D)[1] has been utilized in this document except where major differences occurred and consequently new zoning was required. Zone descriptions are as follows:

A. MLP interior zones for acoustic specifications are listed in table 2-2.
B. SSAT exterior, PCR, and far field zones for acoustic specifications are listed in table 2-3.
C. MLP interior zones for vibration specifications are listed in table 2-4.
D. SSAT exterior zones for vibration specifications are listed in table 2-5.
E. PCR zones for vibration specifications are listed in table 2-6.

The following nomenclature is used to define a zone:

$$\text{Identifier} \longrightarrow \overbrace{\underbrace{X.\ Y.}_{\text{Wide Region}}\quad \underbrace{Z.\ U}_{\text{Narrow Region}}}^{\text{Zone}}$$

The first two identifiers, X.Y, are used to define a wide region. The extent of this region coincides with an acoustic field defined by the average sound pressure level (SPL) spectrum and associated dispersion within this region during characteristic time intervals of a launch. All near field acoustic specifications are presented for zones defined only by the first two identifiers.

Other identifiers, Z.U, are used to narrow the region of definition. The extent of the narrow region is defined by the similarity of structural components expected to exhibit similar vibrational response to the launch-induced excitation. All vibration specifications are presented for zones defined by either three, X.Y.Z, or four, X.Y.Z.U, identifiers.

Far field acoustic specifications are presented without referencing them to any zone since a unique definition of the region of application is given by the radial distance to the center of the MLP.

2.4 CONFIDENCE LEVELS

The confidence levels (C.L.) for the acoustic data are based upon actual data measured during the Saturn V Program. Scaling of these data allows the continued usage of the confidence level at 97.7 percent which signifies a worst case probability of 2.3 percent in which an acoustic level within a zone, at any given frequency, may be exceeded during any one subsequent launch.

Confidence levels were not calculated for the vibration data due to insufficient information. The probability of exceeding the specified vibration levels depicted in SP-4-38-D[1] and in this document will be exceedingly small as the dispersion factors computed during the Saturn V Program were applied to each zone in this document.

Refinements to the confidence levels will be made as the actual data develop.

Table 2-2. MLP Interior Zones for Acoustic Specifications

Zone	Deck	Description	Page
1.0		MLP. Area under the Space Shuttle vehicle.	
1.2	A	Orbiter Holddown. MLP compartments around Orbiter exhaust well.	A-2,3
1.2	A	Orbiter Holddown. MLP compartments except vicinity of Orbiter exhaust well.	A-4,5
1.2	A	Lift-off steady state until umbilical disconnect. MLP compartments around exhaust wells.	A-6,7
1.2	A	Lift-off steady state until umbilical disconnect. MLP compartments 36AB, 37A, and 37B.	A-8,9
1.2	A	Lift-off steady state until umbilical disconnect. MLP compartments except vicinity of exhaust wells.	A-10,11
1.2	A	Lift-off peak. MLP compartments around exhaust wells.	A-12,13
1.2	A	Lift-off peak. MLP compartments 36AB, 37A, and 37B.	A-14,15
1.2	A	Lift-off peak. MLP compartments except vicinity of exhaust wells.	A-16,17
1.3	B	Orbiter Holddown. MLP compartments around Orbiter exhaust well.	A-2,3
1.3	B	Orbiter Holddown. MLP compartments except vicinity of Orbiter exhaust well.	A-4,5
1.3	B	Lift-off steady state until umbilical disconnect. MLP compartments around exhaust wells.	A-6,7
1.3	B	Lift-off steady state until umbilical disconnect. MLP compartments 36AB, 37A, and 37B.	A-8,9
1.3	B	Lift-off steady state until umbilical disconnect. MLP compartments except vicinity of exhaust wells.	A-10,11
1.3	B	Lift-off peak. MLP compartments around exhaust wells.	A-12,13

Table 2-2. MLP Interior Zones for Acoustic Specifications (cont)

Zone	Deck	Description	Page
1.3	B	Lift-off peak. MLP compartments 36AB, 37A, and 37B.	A-14,15
1.3	B	Lift-off peak. MLP compartments except vicinity of exhaust wells.	A-16,17
2.2	A	Orbiter Holddown. MLP compartments except vicinity of Orbiter exhaust well.	A-4,5
2.2	A	Lift-off steady state until umbilical disconnect. MLP compartments except vicinity of exhaust wells.	A-10,11
2.2	A	Lift-off peak. MLP compartments except vicinity of exhaust wells.	A-16,17
2.3	B	Orbiter Holddown. MLP compartments except vicinity of Orbiter exhaust well.	A-4,5
2.3	B	Lift-off steady state until umbilical disconnect. MLP compartments except vicinity of exhaust wells.	A-10,11
2.3	B	Lift-off. MLP compartments except vicinity of exhaust wells.	A-16,17

Table 2-3. SSAT Exterior, PCR, and Far Field Zones for Acoustic Specifications

Zone	Description	Page
3.0	SSAT (all levels).	
3.0	Orbiter holddown.	A-18, 19
3.0	Lift-off steady state until umbilical disconnect.	A-20, 21
3.0	Lift-off peak.	A-22, 23
4.0	PCR structure.	
4.0	Orbiter holddown, side 4.	A-18, A-19
4.0	Lift-off steady state until umbilical disconnect, side 4	A-20, A-21
4.0	Lift-off peak, side 4.	A-24, A-25
4.0	Orbiter holddown, sides 1, 2, and 3.	A-26 thru A-31
4.0	Lift-off steady state until umbilical disconnect, sides 1, 2, and 3.	A-32 thru A-37
4.0	Lift-off peak, sides 1, 2, and 3.	A-38 thru A-43
4.3	Orbiter holddown, PCR interior above level 130.6.	A-44, A-45
4.3	Lift-off steady state until umbilical disconnect, PCR interior above level 130.6.	A-46, A-47
4.3	Lift-off peak, PCR interior above level 130.6.	A-48, A-49
---	Far field predicted average sound pressure levels (50 percent C.L.).	A-50, A-51
---	Far field acoustical specification (97.7 percent C.L.).	A-52, A-53

Table 2-4. MLP Interior Zones for Vibration Specifications

Zone	Deck	Description	Page		
			X	Y	Z
1.1	0	Launcher Deck. Area under the Space Shuttle Vehicle.			
1.1.1	0	Launcher Deck. Exhaust well area.			
1.1.1.1	0	Launcher Deck. Ceiling of compartments 33A, 34A, 43A, and 44A.	B-2	B-3	B-4
1.1.1.2	0	Launcher Deck. Ceiling of compartments 35AB, 38AB, and 39AB.	B-2	B-3	B-5
1.1.1.3	0	Launcher Deck. Ceiling of compartments 30AB, 31A, 32AB, 40AB, 41A, 42AB, 46AB, and 47AB.	B-2	B-3	B-6
1.1.1.4	0	Launcher Deck. Ceiling of compartments 36AB and 37A.	B-2	B-3	B-7
1.1.2	0	Launcher Deck. Area remote from exhaust wells.			
1.1.2.1	0	Launcher Deck. Ceiling of compartments 2A and 16A.	B-2	B-3	B-8
1.2	A	Area under the Space Shuttle Vehicle.			
1.2.1	A	Exhaust well area.			
1.2.1.1	A	Floor beams supporting grating, compartments 33A, 34A, 43A, and 44A.	B-9	B-10	B-11
1.2.1.2	A	Floor beams supporting grating, compartments 31A, and 41A.	B-12	B-13	B-14
1.2.1.3	A	Floor beams supporting grating, compartment 37A.	B-15	B-16	B-17
1.2.2	A	Main floor structure, compartments 2A and 16A.	B-18	B-18	B-19

Table 2-4. MLP Interior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
1.2.2.1	A	Base of Instrumentation Power Unit substation and base of Industrial Power Unit substation. Compartment 16A.	B-20	B-20	B-21
1.2.3	A	Orbiter exhaust well walls, compartments 33A, 34A, 35AB, 38AB, 39AB, 43A, and 44A. Girder web stiffener.	B-54 B-48	B-49 B-55	B-52 B-51& B-52
1.2.3.1	A	Orbiter exhaust well walls, compartments 33A, 34A, 35AB, 38AB, 39AB, 43A, and 44A. Girder web plate.	B-56 B-48	B-49 B-57	B-52 B-51& B-52
1.2.4	A	SRB exhaust well walls, compartments 30AB, 31A, 35AB, 39AB, 40AB, and 41A. Girder web stiffener.	B-48 B-59	B-58 B-49	B-52 B-52
1.2.4.1	A	SRB exhaust well walls, compartments 30AB, 31A, 35AB, 39AB, 40AB, and 41A. Girder web plate.	B-60 B-48	B-49 B-61	B-52 B-52
1.2.5	A	SRB exhaust well walls, compartments 36AB and 37A. Girder web stiffener.	B-62	B-49	B-52
1.2.5.1	A	SRB exhaust well walls, compartments 36AB and 37A. Girder web plate.	B-63	B-49	B-52
1.2.6	A	SRB exhaust well walls, compartments 46AB and 47AB. Girder web stiffener.	B-48	B-64	B-52
1.2.6.1	A	SRB exhaust well walls, compartments 46AB and 47AB. Girder web plate.	B-48	B-65	B-52
1.2.7	A	Inner walls between compartments 32AB, 35AB, and 33A; between 33A and 34A; between 34A and exterior girder on side 1; between 39AB, 42AB, and 43A; between 43A and 44A; between 44A and exterior girder on side 1. Girder web stiffener.	B-48	B-66	B-51& B-52

Table 2-4. MLP Interior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
1.2.7.1	A	Inner walls between compartments 32AB, 35AB, and 33A; between 33A and 34A; between 34A and exterior girder on side 1; between 39AB, 42AB, and 43A; between 43A and 44A; between 44A and exterior girder on side 1. Girder web plate.	B-48	B-67	B-51& B-52
1.2.8	A	Inner walls between compartments 30AB and 31A; between 31A and 32AB; between 40AB and 41A; between 41A and 42AB. Girder web stiffener.	B-48	B-68	B-52
1.2.8.1	A	Inner walls between compartments 30AB and 31A; between 31A and 32AB; between 40A and 41A; between 41A and 42AB. Girder web plate.	B-48	B-69	B-52
1.2.9	A	Inner walls between compartments 36AB and 37A; between 37A and 38AB. Girder web stiffener.	B-48	B-70	B-52
1.2.9.1	A	Inner walls between compartments 36AB and 37A; between 37A and 38AB. Girder web plate.	B-48	B-71	B-52
1.2.10	A	Inner walls between compartments 32AB and 35AB; between 35AB and 38AB; between 38AB and 39AB; between 39AB and 42AB. Girder web stiffener.	B-72	B-49	B-52
1.2.10.1	A	Inner walls between compartments 32AB and 35AB; between 35AB and 38AB; between 38AB and 39AB; between 39AB and 42AB. Girder web plate.	B-73	B-49	B-52
1.2.11	A	Inner walls between compartments 30AB, 31A, 32AB, 33A, 34A, 45AB, and 2A; between 40AB, 41A, 42AB, 43A, 44A, 45AB, and 16A. Girder web stiffener.	B-74	B-49	B-51

Table 2-4. MLP Interior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
1.2.11.1	A	Inner walls between compartments 30AB, 31A, 32AB, 33A, 34A, 45AB, and 2A; between 40AB, 41A, 42AB, 43A, 44A, 45AB, and 16A. Girder web plate.	B-75	B-49	B-51
1.2.12	A	Exterior walls, compartment 2A, side 4 and compartment 16A, side 2. Girder web stiffener.	B-76	B-49	B-51
1.2.12.1	A	Exterior walls, compartment 2A, side 4 and compartment 16A, side 2. Girder web plate.	B-77	B-49	B-51
1.2.13	A	Exterior wall, compartments 2A, 45AB, and 16A, side 1 of MLP. Girder web stiffener.	B-48	B-78	B-51
1.2.13.1	A	Exterior wall, compartments 2A, 45AB, and 16A, side 1 of MLP. Girder web plate.	B-48	B-79	B-51
1.2.14	A	Inner walls between compartments 1A and 2A; between 19A and 16A. Girder web stiffener.	B-48	B-80	B-53
1.2.14.1	A	Inner walls between compartments 1A and 2A; between 19A and 16A. Girder web plate.	B-48	B-81	B-53
1.2.15	A	Inner walls between compartments 30AB, 46AB, and 9A; between 36AB, 47AB, and 21A; between 40AB and 18A. Girder web stiffener.	B-48	B-82	B-51
1.2.15.1	A	Inner walls between compartments 30AB, 46AB, and 9A; between 36AB, 47AB, and 21A; between 40AB and 18A. Girder web plate.	B-48	B-83	B-51

Table 2-4. MLP Interior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page X	Page Y	Page Z
1.2.16	A	Inner walls between compartments 30AB and 46AB; between 46AB and 36AB; between 36AB and 47AB; between 47AB and 40AB. Girder web stiffener.	B-84	B-49	B-52
1.2.16.1	A	Inner walls between compartments 30AB and 46AB; between 46AB and 36AB; between 36AB and 47AB; between 47AB and 40AB. Girder web plate.	B-85	B-49	B-52
1.3	B	Area under the Space Shuttle vehicle.			
1.3.1	B	Exhaust well area.			
1.3.1.1	B	Floor structure (floor beams and decking), compartments 33B, 34B, 43B, and 44B.	B-22	B-23	B-24
1.3.1.2	B	Floor structure (floor beams and decking), compartments 35AB, 38AB, and 39AB.	B-22	B-23	B-25
1.3.1.3	B	Floor structure (floor beams and decking), compartments 30AB, 31B, 32AB, 40AB, 41B, 42AB, 46AB, and 47AB.	B-22	B-23	B-26
1.3.1.4	B	Floor structure (floor beams and decking), compartments 36AB and 37AB.	B-22	B-23	B-27
1.3.1.5	B	Floor structure, compartment 45AB.	B-22	B-23	B-28
1.3.2	B	Floor structure (floor beams and decking), compartments 2B and 16B.	B-22	B-23	B-29
1.3.3	B	Orbiter exhaust well walls, compartments 33B, 34B, 35AB, 38AB, 39AB, 43B, and 44B. Girder web stiffener.	B-54 B-48	B-49 B-55	B-52 B-51& B-52
1.3.3.1	B	Orbiter exhaust well walls, compartments 33B, 34B, 35AB, 38AB, 39AB, 43B, and 44B. Girder web plate.	B-56 B-48	B-49 B-57	B-52 B-51& B-52

Table 2-4. MLP Interior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
1.3.4	B	SRB exhaust well walls, compartments 30AB, 31B, 35AB, 39AB, 40AB, and 41B. Girder web stiffener.	B-48 B-59	B-58 B-49	B-52 B-52
1.3.4.1	B	SRB exhaust well walls, compartments 30AB, 31B, 35AB, 39AB, 40AB, and 41B. Girder web plate.	B-60 B-48	B-49 B-61	B-52 B-52
1.3.5	B	SRB exhaust well walls, compartments 36AB and 37B. Girder web stiffener.	B-62	B-49	B-52
1.3.5.1	B	SRB exhaust well walls, compartments 36AB and 37B. Girder web plate.	B-63	B-49	B-52
1.3.6	B	SRB exhaust well walls, compartments 46AB and 47AB. Girder web stiffener.	B-48	B-64	B-52
1.3.6.1	B	SRB exhaust well walls, compartments 46AB and 47AB. Girder web plate.	B-48	B-65	B-52
1.3.7	B	Inner walls between compartments 32AB, 35AB, and 33B; between 33B and 34B; between 34B and exterior girder on side 1; between 39AB, 42AB, and 43B; between 43B and 44B; between 44B and exterior girder on side 1. Girder web stiffener.	B-48	B-66	B-51& B-52
1.3.7.1	B	Inner walls between compartments 32AB, 35AB, and 33B; between 33B and 34B; between 34B and exterior girder on side 1; between 39AB, 42AB, and 43B; between 43B and 44B; between 44B and exterior girder on side 1. Girder web plate.	B-48	B-67	B-51& B-52
1.3.8	B	Inner walls between compartments 30AB and 31B; between 31B and 32AB; between 40AB and 41B; between 41B and 42AB. Girder web stiffener.	B-48	B-68	B-52

Table 2-4. MLP Interior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
1.3.8.1	B	Inner walls between compartments 30AB and 31B; between 31B and 32AB; between 40AB and 41B; between 41B and 42AB. Girder web plate.	B-48	B-69	B-52
1.3.9	B	Inner walls between compartments 36AB and 37B; between 37B and 38AB. Girder web stiffener.	B-48	B-70	B-52
1.3.9.1	B	Inner walls between compartments 36AB and 37B; between 37B and 38AB. Girder web plate.	B-48	B-71	B-52
1.3.10	B	Inner walls between compartments 32AB and 35AB; between 35AB and 38AB; between 38AB and 39AB; between 39AB and 42AB. Girder web stiffener.	B-72	B-49	B-52
1.3.10.1	B	Inner walls between compartments 32AB and 35AB; between 35AB and 38AB; between 38AB and 39AB; between 39AB and 42AB. Girder web plate.	B-73	B-49	B-52
1.3.11	B	Inner walls between compartments 30AB, 31B, 32AB, 33B, 34B, 45AB, and 2B; between 40AB, 41B, 42AB, 43B, 44B, 45AB, and 16B. Girder web stiffener.	B-74	B-49	B-51
1.3.11.1	B	Inner walls between compartments 30AB, 31B, 32AB, 33B, 34B, 45AB, and 2B; between 40AB, 41B, 42AB, 43B, 44B, 45AB, and 16B. Girder web plate.	B-75	B-49	B-51
1.3.12	B	Exterior walls, compartment 2B, side 4 and compartment 16B, side 2. Girder web stiffener.	B-76	B-49	B-51
1.3.12.1	B	Exterior walls, compartment 2B, side 4 and compartment 16B, side 2. Girder web plate.	B-77	B-49	B-51

Table 2-4. MLP Interior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
1.3.13	B	Exterior wall, compartments 2B and 16B, side 1 of MLP. Girder web stiffener.	B-48	B-78	B-51
1.3.13.1	B	Exterior wall, compartments 2B and 16B, side 1 of MLP. Girder web plate.	B-48	B-79	B-51
1.3.14	B	Inner walls between compartments 1B and 2B; between 15B and 16B. Girder web stiffener.	B-48	B-80	B-53
1.3.14.1	B	Inner walls between compartments 1B and 2B; between 15B and 16B. Girder web plate.	B-48	B-81	B-53
1.3.15	B	Inner walls between compartments 30AB and 21B; between 21B, 22B, and 46AB; between 36AB, 47AB, 40AB, and 9B. Girder web stiffener.	B-48	B-82	B-51
1.3.15.1	B	Inner walls between compartments 30AB and 21B; between 21B, 22B, and 46AB; between 36AB, 47AB, 40AB, and 9B. Girder web plate.	B-48	B-83	B-51
1.3.16	B	Inner walls between compartments 30AB and 46AB; between 46AB and 36AB; between 36AB and 47AB; between 47AB and 40AB. Girder web stiffener.	B-84	B-49	B-52
1.3.16.1	B	Inner walls between compartments 30AB and 46AB; between 46AB and 36AB; between 36AB and 47AB; between 47AB and 40AB. Girder web plate.	B-85	B-49	B-52
2.1	0	Launcher Deck. Area between SRB exhaust wells and side 3 of MLP.			
2.1.1	0	Launcher Deck, main floor structure. Ceiling of compartments 1A, 7A, 8A, 9A, 10A, 15A, 17A, 18A, 19A, 20A, and 21A.	B-30	B-31	B-32

Table 2-4. MLP Interior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
2.2	A	Area between SRB exhaust wells and side 3 of MLP.			
2.2.1	A	Shock mounted floors.			
2.2.1.1	A	Shock mounted floors, compartment 15A.	B-33	B-33	B-34
2.2.1.2	A	Shock mounted floors, compartments 1A, 7A, 8A, 9A, and 10A.	B-35	B-35	B-36
2.2.2	A	Main floor beams supporting shock mounted floors, compartments 1A, 7A, 8A, 9A, 10A, and 15A. Ceiling of level B.	B-37	B-37	B-38
2.2.2.1	A	Elevated floor structure, compartments 18A and 19A.	B-39	B-39	B-40
2.2.2.2	A	Elevated floor structure, compartment 21A.	B-39	B-39	B-41
2.2.3	A	Exterior wall, compartments 1A, 7A, and 15A, side 3 of MLP. Girder web stiffener.	B-48	B-86	B-53
2.2.3.1	A	Exterior wall, compartments 1A, 7A, and 15A, side 3 of MLP. Girder web plate.	B-48	B-87	B-53
2.2.4	A	Exterior walls, compartments 1A, side 4 and 15A, side 2. Girder web stiffener.	B-88	B-50	B-53
2.2.4.1	A	Exterior walls, compartments 1A, side 4 and 15A, side 2. Girder web plate.	B-89	B-50	B-53
2.2.5	A	Inner walls between compartments 7A, 8A, 9A and 1A; between 7A, 10A, and 15A; between 18A and 19A. Girder web stiffener.	B-90	B-50	B-53

Table 2-4. MLP Interior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
2.2.5.1	A	Inner walls between compartments 7A, 8A, 9A, and 1A; between 7A, 10A, and 15A; between 18A and 19A. Girder web plate.	B-91	B-50	B-53
2.2.5.2	A	Inner wall partitions, compartments 18A and 21A.	B-92 B-48	B-50 B-93	B-53 B-53
2.2.5.3	A	Inner wall partitions, compartments 10A and 20A.	B-94 B-48	B-50 B-95	B-53 B-53
2.3	B	Area between SRB exhaust wells and side 3 of MLP.			
2.3.1	B	Shock mounted floors, compartments 7B, 8B, 9B, 10B, 15B, 21B, and 22B.	B-42	B-42	B-43
2.3.2	B	Main floor structure, compartment 1B.	B-44	B-45	B-46
2.3.2.1	B	Elevated framing, compartment 1B.	B-44	B-45	B-47
2.3.3	B	Exterior wall, compartments 1B, 7B, and 15B, side 3 of MLP. Girder web stiffener.	B-48	B-86	B-53
2.3.3.1	B	Exterior wall, compartments 1B, 7B, and 15B, side 3 of MLP. Girder web plate.	B-48	B-87	B-53
2.3.4	B	Exterior walls, compartments 1B, side 4 and 15B, side 2. Girder web stiffener.	B-88	B-50	B-53
2.3.4.1	B	Exterior walls, compartments 1B, side 4 and 15B, side 2. Girder web plate.	B-89	B-50	B-53
2.3.5	B	Inner walls between compartments 7B, 8B, 21B and 1B; between 7B, 10B, 9B, and 15B. Girder web stiffener.	B-90	B-50	B-53
2.3.5.1	B	Inner walls between compartments 7B, 8B, 21B, and 1B; between 7B, 10B, 9B, and 15B. Girder web plate.	B-91	B-50	B-53

Table 2-5. SSAT Exterior Zones for Vibration Specifications

Zone	Deck	Description	Page		
			X	Y	Z
3.0		SSAT structure.			
3.1.1	75	Floor beam structure and grating.	B-96	B-96	B-97
3.1.2	95	Floor beam structure and grating, outside of 3-ft. zone on side 1.	B-96	B-96	B-98
3.1.2.1	95	Floor beam structure and grating, within 3-ft. zone on side 1.	B-96	B-96	B-99
3.1.2.2	95	LN_2 dewar and valve complex near corner 2-3.	B-100	B-100	B-101
3.1.3	115	Floor beam structure and grating, outside of 3-ft. zone on side 1.	B-96	B-96	B-98
3.1.3.1	115	Floor beam structure and grating, within 3-ft. zone on side 1.	B-96	B-96	B-99
3.1.4	135	Floor beam structure and grating, outside of 3-ft. zone on side 1.	B-96	B-96	B-98
3.1.4.1	135	Floor beam structure and grating, within 3-ft. zone on side 1.	B-96	B-96	B-99
3.1.5	155	Floor beam structure and grating, outside of 3-ft. zone on side 1.	B-96	B-96	B-102
3.1.5.1	155	Floor beam structure and grating, within 3-ft. zone on side 1.	B-96	B-96	B-103
3.1.5.2	155	LH_2 dewar and valve complex near corner 2-3.	B-104	B-104	B-105
3.1.5.3	155	LOX dewar and valve complex near corner 3-4.	B-106	B-106	B-107
3.1.6	175	Floor beam structure and grating, outside of 3-ft. zone on side 1.	B-96	B-96	B-102
3.1.6.1	175	Floor beam structure and grating, within 3-ft. zone on side 1.	B-96	B-96	B-103

Table 2-5. SSAT Exterior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
3.1.7	195	Floor beam structure and grating, outside of 3-ft. zone on side 1.	B-96	B-96	B-102
3.1.7.1	195	Floor beam structure and grating, within 3-ft. zone on side 1.	B-96	B-96	B-103
3.1.8	215	Floor beam structure and grating, outside of 3-ft. zone on side 1.	B-96	B-96	B-102
3.1.8.1	215	Floor beam structure and grating, within 3-ft. zone on side 1.	B-96	B-96	B-103
3.1.9	235	Floor beam structure and grating, outside of 3-ft. zone on side 1.	B-96	B-96	B-102
3.1.9.1	235	Floor beam structure and grating, within 3-ft. zone on side 1.	B-96	B-96	B-103
3.1.10	255	Floor beam structure and grating, outside of 3-ft. zone on side 1.	B-96	B-96	B-102
3.1.10.1	255	Floor beam structure and grating, within 3-ft. zone on side 1.	B-96	B-96	B-103
3.1.11	275	Floor beam structure and grating, outside of 3-ft. zone on side 1.	B-96	B-96	B-102
3.1.11.1	275	Floor beam structure and grating, within 3-ft. zone on side 1.	B-96	B-96	B-103
3.1.11.2	275	Elevator Equipment Room floor structure.	B-108	B-108	B-109
3.1.12	295	Floor beam structure.	B-110	B-110	B-111
3.2		Service Arm Structure on SSAT.			
3.2.1	195	Orbiter Egress Arm	B-112	B-113	B-114
3.2.2	215	Intertank Access Arm	B-115	B-116	B-117
3.3		Cabinets and enclosures on SSAT.			

Table 2-5. SSAT Exterior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
3.3.1	75	Test specification for vibration input at the base of cabinets.	B-118 B-120	B-118 B-120	B-119 B-121
3.3.1.1	75	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-126 B-128
3.3.2	95	Test specification for vibration input at the base of cabinets.	B-118 B-120	B-118 B-120	B-119 B-121
3.3.2.1	95	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-126 B-128
3.3.3	115	Test specification for vibration input at the base of cabinets.	B-118 B-120	B-118 B-120	B-119 B-121
3.3.3.1	115	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-126 B-128
3.3.4	135	Test specification for vibration input at the base of cabinets.	B-122 B-124	B-122 B-124	B-123 B-125
3.3.4.1	135	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-127 B-129
3.3.5	155	Test specification for vibration input at the base of cabinets.	B-122 B-124	B-122 B-124	B-123 B-125
3.3.5.1	155	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-127 B-129
3.3.6	175	Test specification for vibration input at the base of cabinets.	B-122 B-124	B-122 B-124	B-123 B-125
3.3.6.1	175	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-127 B-129

Table 2-5. SSAT Exterior Zones for Vibration Specifications (cont)

Zone	Deck	Description	Page		
			X	Y	Z
3.3.7	195	Test specification for vibration input at the base of cabinets.	B-122 B-124	B-122 B-124	B-123 B-125
3.3.7.1	195	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-127 B-129
3.3.8	215	Test specification for vibration input at the base of cabinets.	B-122 B-124	B-122 B-124	B-123 B-125
3.3.8.1	215	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-127 B-129
3.3.9	235	Test specification for vibration input at the base of cabinets.	B-122 B-124	B-122 B-124	B-123 B-125
3.3.9.1	235	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-127 B-129
3.3.10	255	Test specification for vibration input at the base of cabinets.	B-122 B-124	B-122 B-124	B-123 B-125
3.3.10.1	255	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-127 B-129
3.3.11	275	Test specification for vibration input at the base of cabinets.	B-122 B-124	B-122 B-124	B-123 B-125
3.3.11.1	275	Predicted envelope of vibration output at the center of cabinet tops. Not a test specification.			B-127 B-129

Table 2-6. PCR Zoning for Vibration Specifications

Zone	Level	Description	Page X'	Page Y'	Page Z'
4.0		Rotary bridge and PCR structures			
4.1		PCR floors at level 107.0			
4.1.1	107.0	Outside platform on side 2 of PCR	B-130	B-130	B-131
4.1.2	107.0	Outside platform on side 4 of PCR	B-130	B-130	B-132
4.1.3	107.0	APS servicing platform	B-130	B-130	B-133
4.2		PCR floors at level 120.0 and 117.0			
4.2.1	120.0	APU servicing platform on side 2 of PCR	B-134	B-134	B-135
4.2.2	120.0	APU servicing platform on side 4 of PCR	B-134	B-134	B-136
4.2.3	120.0	APU servicing platform on side 1 of PCR	B-134	B-134	B-137
4.2.3.1	120.0	Interior walkway area	B-138	B-138	B-139
4.2.3.2	117.0	Hypergol electrical equipment platform	B-138	B-138	B-140
4.3		PCR floors at levels 130.6 and 131.1			
4.3.1	131.1	Outside platform on side 2 of PCR	B-141	B-141	B-142
4.3.2	131.1	Outside platform on side 4 of PCR	B-141	B-141	B-143
4.3.3	130.6	PCR main floor	B-141	B-141	B-144
4.4		PCR roof structure			
4.4.1	206.5	PCR roof portions near sides 2 and 4	B-145	B-145	B-146
4.4.2	206.5 and 207.0	Central portion of PCR roof and hoist equipment room floor	B-145	B-145	B-147
4.4.3	207.2	RCS room floor structure	B-145	B-145	B-148
4.4.4	237.0	RCS room roof structure	B-149	B-149	B-150
4.4.5	220.4	Hoist equipment room roof structure	B-149	B-149	B-151

Table 2-6. PCR Zoning for Vibration Specifications (cont)

Zone	Level	Description	Page		
			X'	Y'	Z'
4.5		PCR wall structure			
4.5.1	130 thru 206	PCR walls on side 1. Girt structure.	B-152	B-153	B-152
4.5.2	107 thru 206	PCR wall on side 2. Area within 15 feet from side 1. Girt structure.	B-154	B-156	B-156
4.5.2.1	107 thru 206	PCR wall on side 2. Area within 35 feet from side 3. Girt structure	B-155	B-156	B-156
4.5.3	107 thru 206	PCR wall on side 3. Girt structure	B-157	B-158	B-157
4.5.4	107 thru 206	PCR wall on side 4. Area within 15 feet from side 1. Girt structure	B-159	B-161	B-161
4.5.4.1	107 thru 206	PCR wall on side 4. Area within 35 feet from side 3. Girt structure	B-160	B-161	B-161
4.6		RCS room walls			
4.6.1	207 thru 237	RCS room wall on side 1. Girt structure	B-162	B-163	B-164
4.6.2	207 thru 237	RCS room wall on side 2. Girt structure	B-165	B-166	B-164
4.6.3	207 thru 237	RCS room wall on side 3. Girt structure	B-162	B-167	B-164
4.6.4	207 thru 237	RCS room wall on side 4. Girt structure	B-168	B-166	B-164

Table 2-6. PCR Zoning for Vibration Specifications (cont)

Zone	Level	Description	Page		
			X'	Y'	Z'
4.7		Hoist Equipment Room walls			
4.7.1	207 thru 220	Hoist equipment room walls on side 1. Girt structure	B-169	B-170	B-171
4.7.2	207 thru 220	Hoist equipment room walls on side 2. Girt structure	B-172	B-173	B-171
4.7.3	207 thru 220	Hoist equipment room walls on side 3. Girt structure	B-169	B-174	B-171
4.7.4	207 thru 220	Hoist equipment room walls on side 4.	B-175	B-173	B-171

SECTION III

LAUNCH ENVIRONMENT

3.1 CHARACTERISTIC LEVELS OF ENVIRONMENT AND ASSOCIATED TIME INTERVALS

The time history of the launch induced acoustic environment on facilities and GSE consists of three characteristic time intervals which define various stages of a launch. The sequence in which these intervals occur and their duration are related to the engine ignition sequence, the time required for the thrust buildup, and the vehicle ascent velocity. To each of these time intervals there is a corresponding characteristic level of acoustic environment and an associated level of vibrational response to the acoustic input. During each characteristic level of acoustic and vibration environment, the GSE is required to perform certain launch associated functions or to remain in a nonoperational mode and to survive launch environment.

Figure 3-1 shows predicted average time history of the overall sound pressure level (OASPL) in the vicinity of the SSAT. Prediction is based on the observation of similar time histories recorded during Saturn V launches. The assumed averaging time window for the pressure oscillogram is in the order of 0.3 second. Characteristic acoustic levels correspond to the following time intervals within the launch sequence:

A. Orbiter Holddown. Average time duration from ignition of the SSME's until the ignition of the SRB's is between 3.6 and 4.0 seconds.

B. Pseudo Steady State at Lift-off. This time interval begins with SRB ignition. After the ignition transient has subsided, the acoustic levels will remain fairly steady or very slowly rising as the vehicle gains altitude, an undisturbed plume develops, and a sharp rise in the OASPL occurs. The duration of this time interval varies depending on the location on the SSAT. For the purpose of these specifications, operational GSE is considered to be launch critical only until the time of umbilical disconnect, which reduces the effective duration of the pseudo steady state to the order of 1.0 second after the SRB ignition.

C. Lift-off Peak. A lift-off peak is preceded by the rise in the OASPL, after which a gradual decrease follows until the OASPL decays to the ambient level. Since the OASPL is distinctly nonstationary during this time interval, the duration of the peak must be defined through some weighted averaging process. If consideration is given to the cumulative damage effects to which all acoustic levels are contributing, but the GSE testing is conceived at the highest level only, then the weighted time duration of the peak level will be considerably

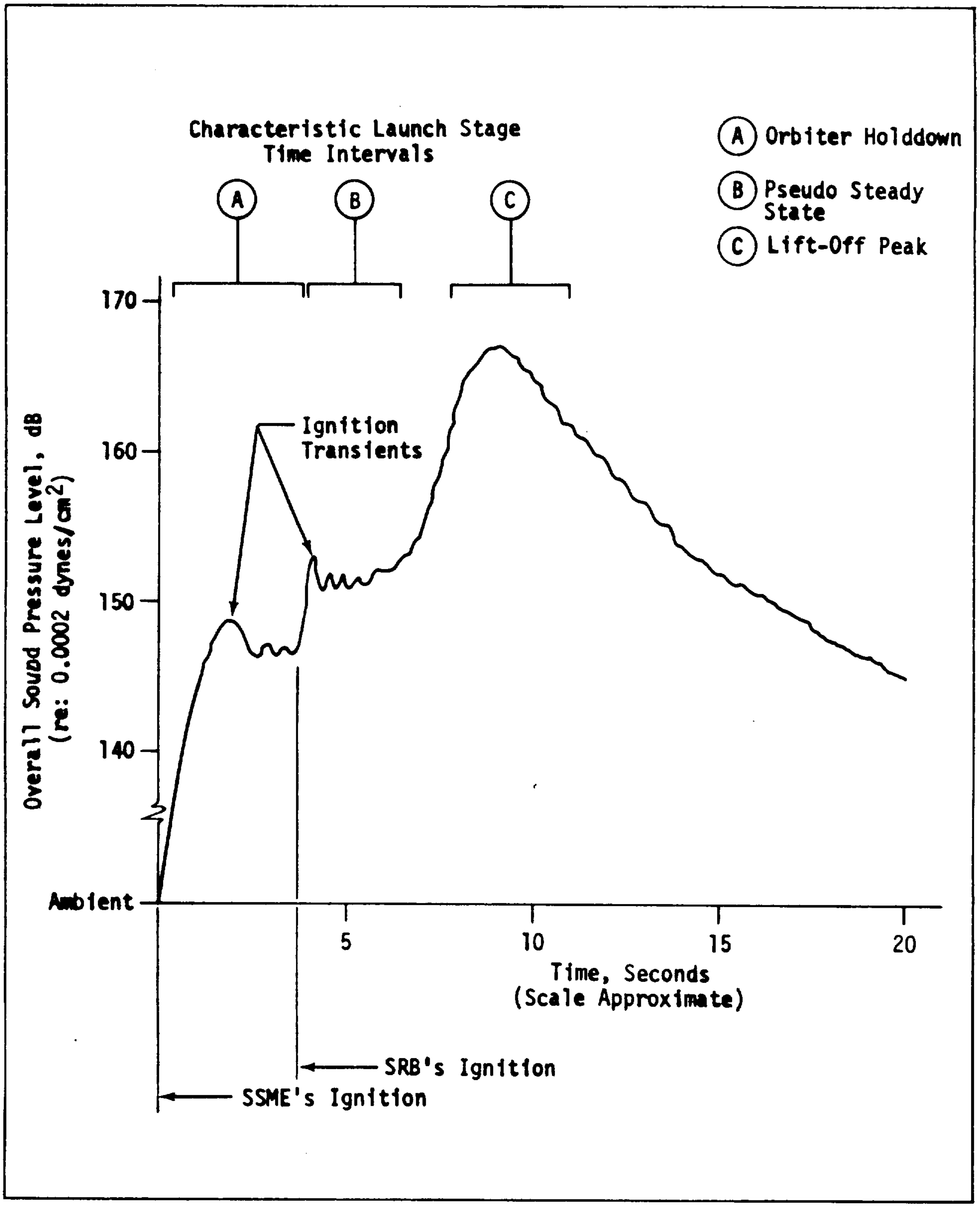


Figure 3-1. Predicted OASPL Time History. Average in the Vicinity of the SSAT

longer than when all test levels are applied in a sequence which considers total duration of the launch environment. For the purpose of these specifications, the duration of the peak level is estimated only as a time interval where the variation of the OASPL remains within N dB for the averaging window in the order of 0.3 second. The results of this estimate for the acoustic field of the SSAT are:

	N (dB)	3	6
Average	Δ T (seconds)	2.3	3.6
97.7% C.L.	Δ T (seconds)	3.2	4.7

The vibration levels follow the pattern of described acoustic levels. These specifications provide vibration levels corresponding to each identified acoustic level.

The ignition transients shown in figure 3-1 are not considered in the specifications. These transients represent pressure pulses with the duration longer than the half period of the lowest natural frequency of any structural component exposed to these pulses. Therefore, the effect of ignition transients on the facilities is essentially that of static loading.

3.2 ACOUSTIC ENVIRONMENT

Launch-induced acoustic environment is defined for each of the characteristic intervals and is presented in Appendix A.

The spectral distribution of acoustic pressures in the frequency domain is presented in terms of octave band sound pressure levels (OBSPL) in decibels, referenced to 0.0002 dynes/cm^2. Two OBSPL curves, the mean and the specification, are presented for each acoustic zone.

The mean OBSPL curve represents a prediction that has a calculated 50 percent probability to exceed at any one octave band center frequency an actual measurement taken anywhere within the zone.

The specification curve represents a prediction that has a calculated 97.7 percent probability to exceed at any one octave band center frequency an actual measurement taken anywhere within the zone.

Predicted acoustic environment was calculated by scaling of Saturn V statistically processed measured data to the environment of the Space Shuttle. Table 2-1 shows rocket engine parameters used to establish scaling ratios and frequency shifts of associated pressure spectral distributions.

3.3 VIBRATION ENVIRONMENT

Launch-induced random vibration environment is presented in Appendix B for each of the characteristic launch stage time intervals, shown in figure 3-1, which correspond to the specified levels of acoustic environment. Random vibration environment specifications are provided for three directions in each zone in accordance with the reference coordinate system X,Y,Z shown in figure 2-2.

For each characteristic launch stage time interval (A, B and C) the specification consists of a wideband, background, acceleration power spectral density (PSD) curve and a superimposed narrow band, ΔPSD, which must be swept over the specified frequency range four times for the duration of a test, providing two upsweeps and two downsweeps in a continuous sequence. The rate of the sweep, in octaves per minute, depends on the duration of the test, which must be established in accordance with Appendix D and consequent revisions thereof.

The wideband acceleration PSD curve is specified within the frequency range of 5 Hz to 2500 Hz.

The waveform with the specified PSD must have a distribution of the instantaneous acceleration amplitudes that approaches a normal (Gaussian) distribution.

The narrow band superimposed ΔPSD has a specified bandwidth Δf of either 25 Hz or 100 Hz. The bandwidth of the sweep may be defined as that between the half power points when the slopes of ΔPSD are in excess of 18 dB per octave.

The range of the superimposed sweep is specified with respect to the arithmetic mean (average) frequency of the specified bandwidth. Thus, a superimposed ΔPSD with a bandwidth of 25 Hz and range of sweep starting at 25 Hz covers at the starting position a theoretical frequency range from 12.5 Hz to 37.5 Hz.

The distribution of the instantaneous acceleration amplitudes of the superimposed waveform with the specified ΔPSD must approach Gaussian distribution whenever the average frequency of the sweep is centered below 200 Hz for Δf = 25 Hz and below 400 Hz for Δf = 100 Hz. At the upper end of the superimposed sweep range, the distribution of the instantaneous accelerations may deteriorate from the Gaussian toward a sinusoidal.

The input to the shaker which controls the specified superimposed mean square acceleration equal to the product of Δf and ΔPSD should be established at the frequencies remote from the distinct resonances of the test item. There is no requirement for the equalization of ΔPSD to the specified level at the distinct resonance frequencies of the test item. In cases when these specifications are used for the purpose of the analytical design, the superimposed sweep may be neglected in the calculations of response.

The overall root mean square (rms) acceleration level, g_{rms}, in units of g, is calculated in these specifications including both PSD and ΔPSD, and within the frequency range from 5Hz to 2500Hz. This level serves only as a relative indicator of the severity of environment, and it is not intended for any comparison between the specified environments having different PSD shapes.

This document also includes a prediction of vibration output at the center of cabinet tops for the cabinets and similar thin-walled enclosures which may be located on the SSAT. This prediction is not a test specification. The cabinets with thin and flat walls, estimated steel sheet metal gage 14 and higher and without the adequate stiffeners, represent a structure sensitive to the direct acoustic input when located within the acoustic field of incident waves. Such structures cannot be adequately tested by the vibration input supplied by the shakers and should be tested in acoustic test facilities. The prediction for the cabinet tops is included as an illustration of the anticipated vibration levels on the cabinet enclosures.

SECTION IV

USAGE INFORMATION

4.1 GENERAL

This section outlines the features of these specifications pertinent to design and testing.

4.2 DESIGN USAGE

The use of these specifications for the design of facilities and GSE requires dynamic analyses of the structure or GSE item in question. An extensive presentation of the state of the art to conduct such analyses is available in "Sonic and Vibration Environment for Ground Facilities - A Design Manual."[9] Numerous other references and reports covering this subject are also available.

The standard procedure of dynamic analysis is to obtain normal modes and associated natural frequencies of the structure, and the distribution of internal forces and stresses due to each normal mode. Depending on the type of environment, acoustic or vibration, these specifications provide two types of inputs to subsequent dynamic analyses which should determine internal forces and stresses expected to occur in the structure subjected to such an environment.

4.2.1 ACOUSTIC SPECIFICATION. The acoustic specification OBSPL curves, when converted to the averaged within the octave bands pressure power spectra, provide input for the calculation of the power spectra of the generalized pressure loads. The conversion from the OBSPL's to pressure power spectrum may be obtained from the graphs provided in the referenced document[9] or calculated by:

$$S_p(f) = \frac{P^2_{rms}}{\Delta f} = \frac{11.894}{f_e} 10^{\frac{OBSPL}{10} - 18} \quad , \text{psi}^2/\text{Hz}$$

Where

$S_p(f)$ = the average value of acoustic pressure spectral density at any frequency f within the octave band with the center frequency f_e.

P^2_{rms} = the mean square pressure within the octave band

$\Delta f = \frac{f_e}{\sqrt{2}}$ = octave bandwidth

OBSPL = the value of octave band sound pressure level, in decibels, at the frequency f_e.

Appendix C, Equations (11) and (12) illustrate the use of acoustic pressure spectra

$$S_p(f) = 2\pi S_p(\omega)$$

in the calculation of the response spectrum. The common assumption of the homogeneous pressure field and the use of assumed space-time correlation functions in the definition of joint acceptance are implied in lieu of measured data. The intended area of application is in the design of facilities having large areas exposed to acoustic pressures, such as PCR and cabinet enclosures.

4.2.2 VIBRATION SPECIFICATION. The vibration specification PSD curves provide vibrational output of the main structure which in the analysis is applied at the supports of the GSE. This input may be used for the calculation of the generalized inertial loads on the GSE, based on the modal analysis of the GSE structure. Solution for the displacement response spectrum relative to supports is usually obtained for the case of motion of a single support, and the response spectra from the motion of multiple supports are superimposed. The intended area of application is in the design of GSE structures and systems for vibration isolation.

The described analytical approach assumes that the specification PSD is not altered by the attachment of another structure, the GSE, to the main supporting structure. The assumption is reasonable and conservative in cases either when the attached mass is small relative to the mass of the main structure or when the distribution of attached masses remains fairly similar to the configuration used on Saturn V/Apollo Program. Otherwise, a very large mass has a tendency to decrease the specification curve.

Due to the random nature of environments, the internal forces and stresses and the displacement amplitudes can be defined only in terms of statistical averages and their spectra. The instantaneous values are random in time while their statistical distribution is very close to Gaussian.

The very complex nature of dynamic analyses required for acceptable accuracy of results is mainly responsible for the proof-of-design testing requirements of which these specifications are a part.

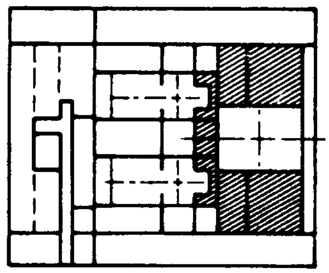
4.3 TESTING USAGE

The acoustic OBSPL curves and the vibration PSD curves are intended to be duplicated by the acoustic and vibration testing facilities in accordance with the tolerances specified in the applicable testing procedure.

In the case of acoustic testing, the degree of duplication of the specified OBSPL's may be restricted by the capability of the testing facility, especially at the lower frequencies of the spectrum and in the case of high OASPL's, such as those encountered on SSAT during the peak lift-off environment. Fortunately, most of the GSE is not susceptible to the direct acoustic excitation and it may not be requieed to undergo acoustic testing. For the equipment which is susceptible to acoustic excitation, such as cabinets containing electronic equipment, acoustic testing should be considered as a supplement to the vibration tests. In each case the decision whether to conduct acoustic testing must be in concurrence with the Directorate of Design Engineering, NASA-KSC.

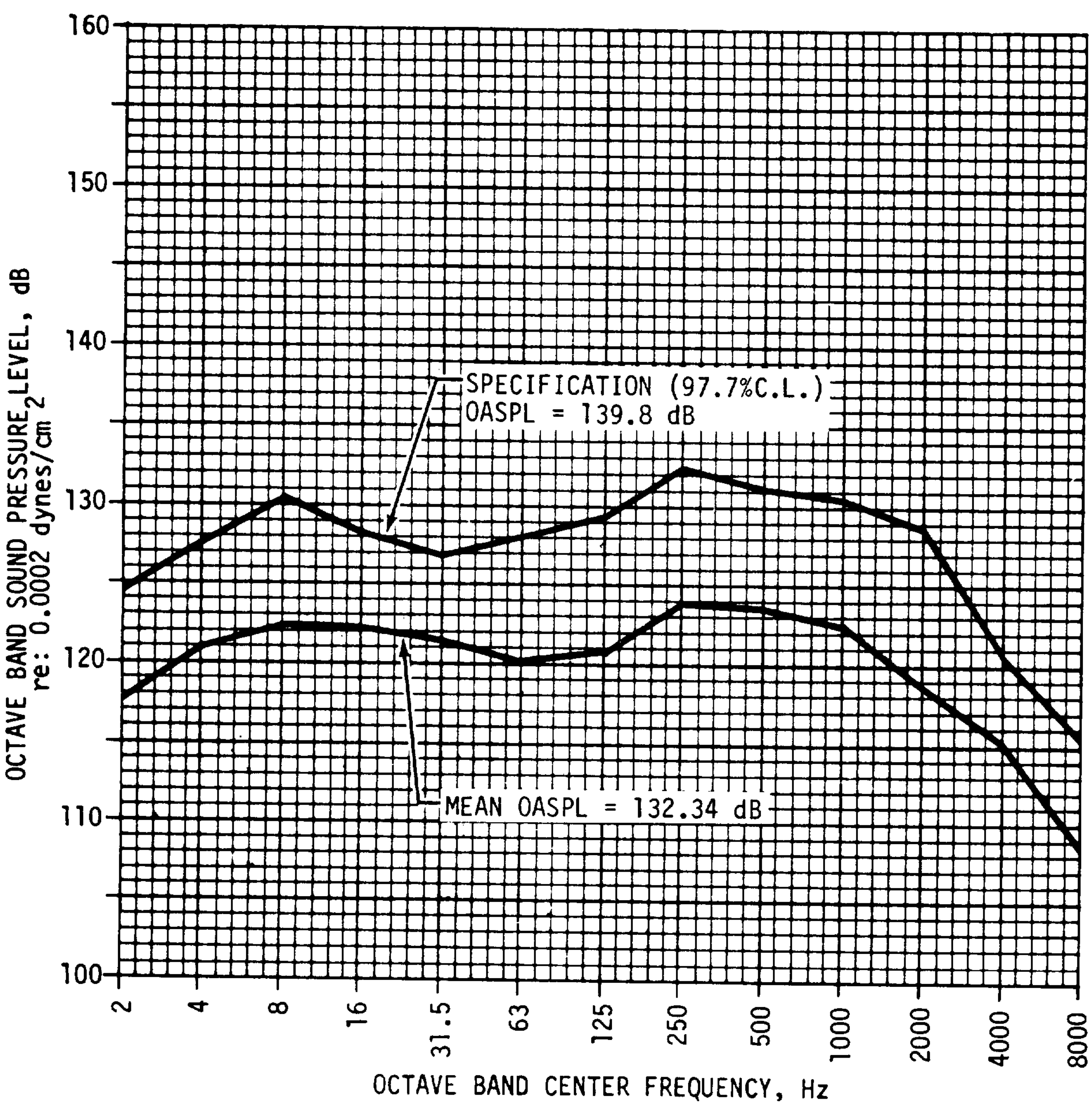
Vibration specification PSD curves predict the worst case vibrational output of the main structure supporting the GSE, with the nominal probability of 2.3 percent that the overall acceleration rms levels may be exceeded anywhere within a zone. The output of the supporting structure, specified as an acceleration PSD, is considered as a driving function applied to the GSE test specimen at the GSE and main structure interface by the vibration generator, usually an electrodynamic shaker. The connection of the GSE test specimen to the shaker fixture should include as a part of the test specimen any mounting hardware, shock isolators, and dampers unique to the actual service installation that would otherwise alter the specified input from the main structure to the test specimen.

If the test item remains nonoperational during a launch, it should be tested only for the highest level of environment corresponding to the peak at lift-off presented in these specifications. If the test item must be operational only during an early stage of the launch, it should be tested in the operational mode for proper functioning under corresponding environment (Orbiter holddown or psedo-steady state); and a second test for survivability in the nonoperational mode under the peak launch environment is also required. In each case when testing of GSE is required, the operational mode of the test item and the corresponding test levels must be established by the user of this document in accordance with the requirements for equipment performance during various stages of a launch.



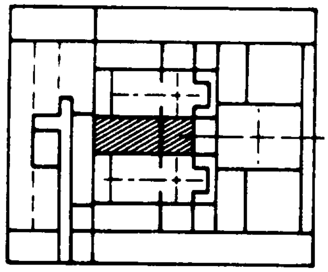
DECKS A & B

ACOUSTICAL SPECIFICATION
ZONE 1.2 AND 1.3
ORBITER HOLDDOWN
MOBILE LAUNCHER PLATFORM COMPARTMENTS
AROUND ORBITER EXHAUST WELL

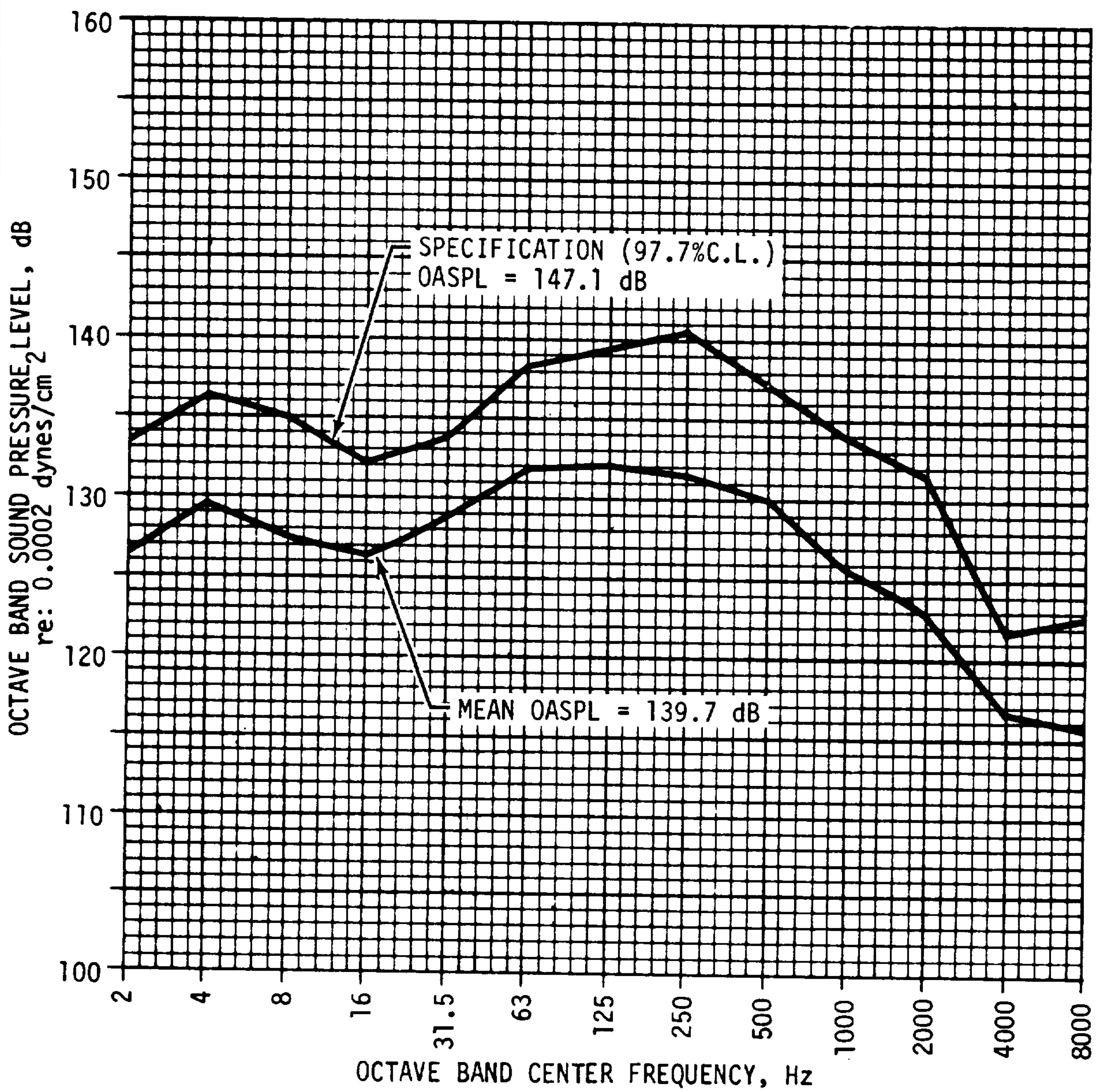


ACOUSTICAL SPECIFICATION
ZONE 1.2 AND 1.3
ORBITER HOLDDOWN
MOBILE LAUNCHER PLATFORM COMPARTMENTS
AROUND ORBITER EXHAUST WELL

Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50%C.L.)	Specification (97.7%C.L.)
2	117.9	124.6
4	120.9	127.7
8	122.4	130.4
16	122.2	128.1
31.5	121.7	126.8
63	121.1	128.0
125	121.6	129.2
250	124.0	132.4
500	123.7	131.0
1000	122.4	130.5
2000	118.5	128.6
4000	114.9	120.3
8000	108.7	115.4
OASPL	132.34	139.8

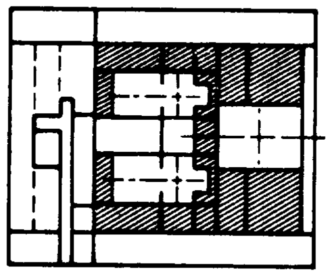


ACOUSTICAL SPECIFICATION
ZONE 1.2 AND 1.3
LIFT-OFF, STEADY STATE UNTIL UMBILICAL DISCONNECT
MOBILE LAUNCHER PLATFORM COMPARTMENTS 36AB, 37A AND 37B

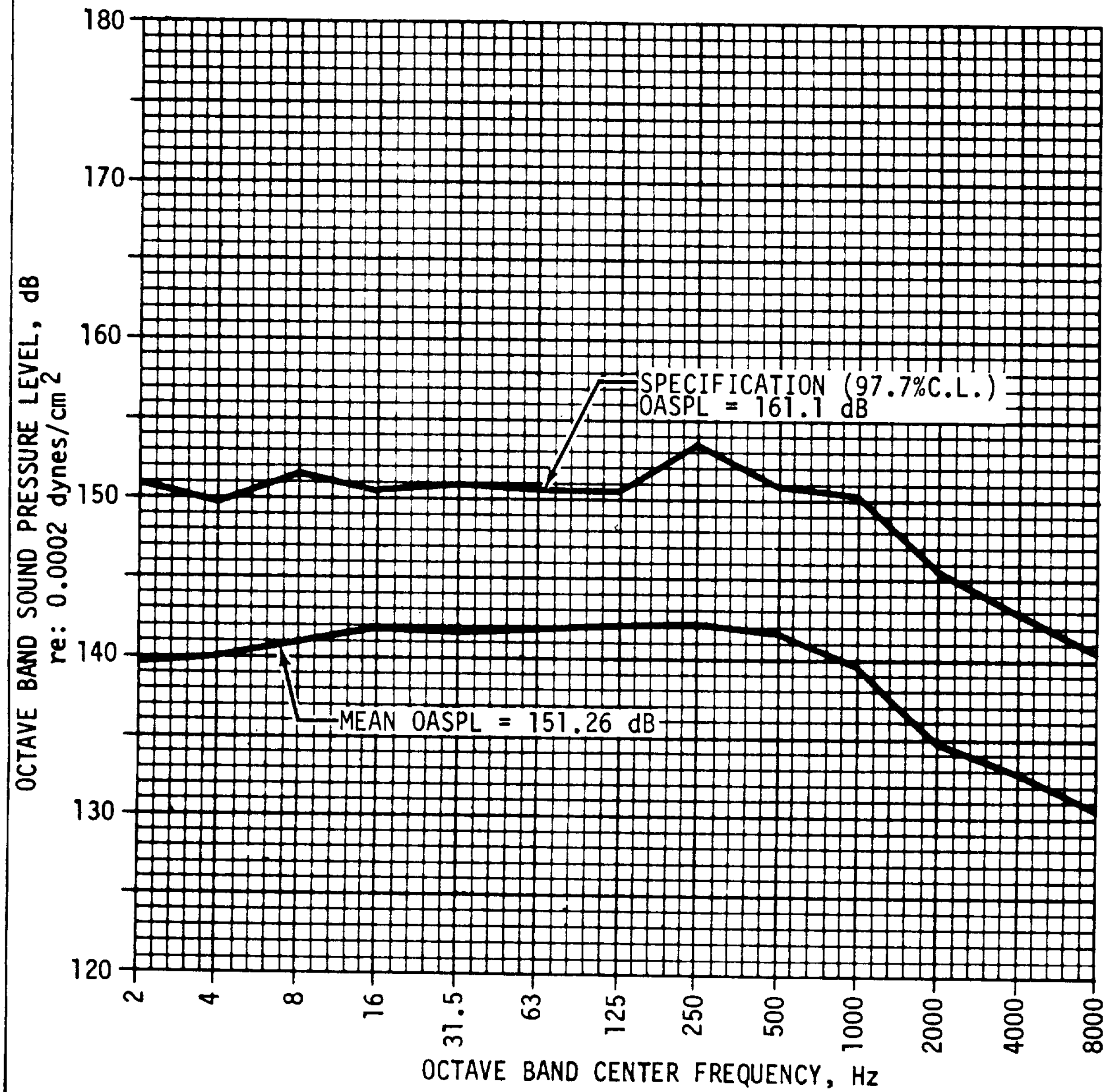


ACOUSTICAL SPECIFICATION
ZONE 1.2 AND 1.3
LIFT-OFF, STEADY STATE UNTIL UMBILICAL DISCONNECT
MOBILE LAUNCHER PLATFORM COMPARTMENTS 36AB, 37A AND 37B

Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50%C.L.)	Specification (97.7%C.L.)
2	126.5	133.2
4	129.4	136.2
8	127.2	135.2
16	126.1	132.0
31.5	128.8	133.9
63	131.6	138.5
125	132.0	139.6
250	131.9	140.3
500	130.0	137.3
1000	126.0	134.1
2000	122.8	131.8
4000	116.2	121.6
8000	115.5	122.2
OASPL	139.7	147.1



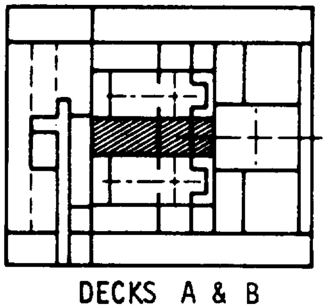
ACOUSTICAL SPECIFICATION
ZONE 1.2 AND 1.3
LIFT-OFF PEAK
MOBILE LAUNCHER PLATFORM COMPARTMENTS
AROUND EXHAUST WELLS

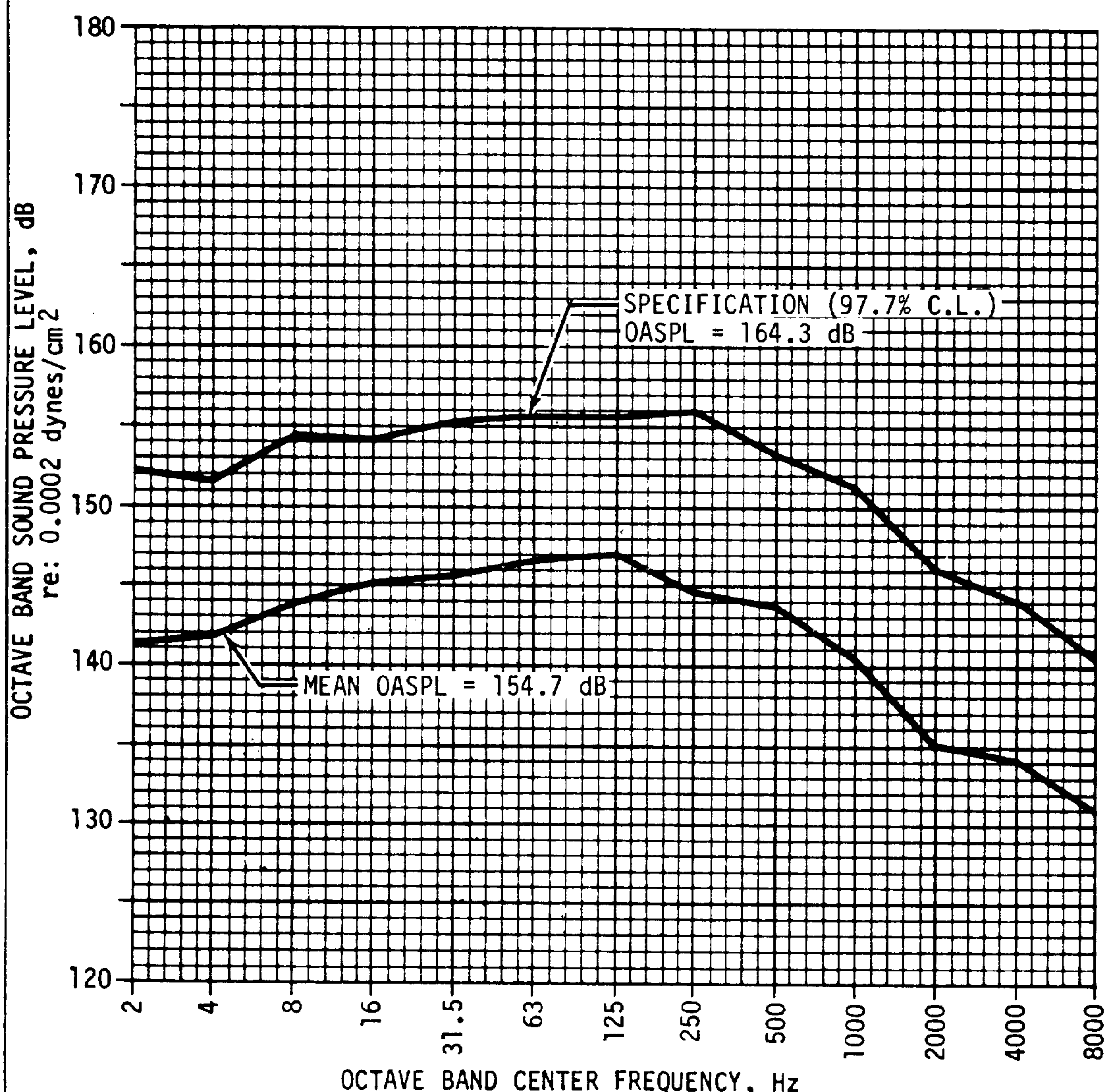


ACOUSTICAL SPECIFICATION
ZONE 1.2 AND 1.3
LIFT-OFF PEAK
MOBILE LAUNCHER PLATFORM COMPARTMENTS
AROUND EXHAUST WELLS

Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50%C.L.)	Specification (97.7%C.L.)
2	139.7	150.7
4	139.8	149.5
8	140.9	151.2
16	141.5	150.4
31.5	141.4	150.7
63	141.6	150.4
125	141.9	150.4
250	142.0	153.3
500	141.5	150.8
1000	139.4	150.1
2000	134.7	145.8
4000	132.6	142.8
8000	130.7	140.6
OASPL	151.26	161.10

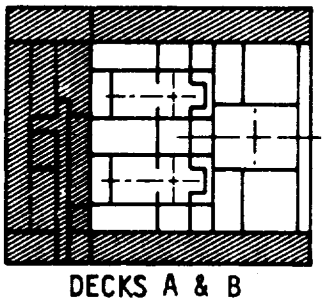
ACOUSTICAL SPECIFICATION
ZONE 1.2 AND 1.3
LIFT-OFF PEAK
MOBILE LAUNCHER PLATFORM COMPARTMENTS 36AB,
37A AND 37B



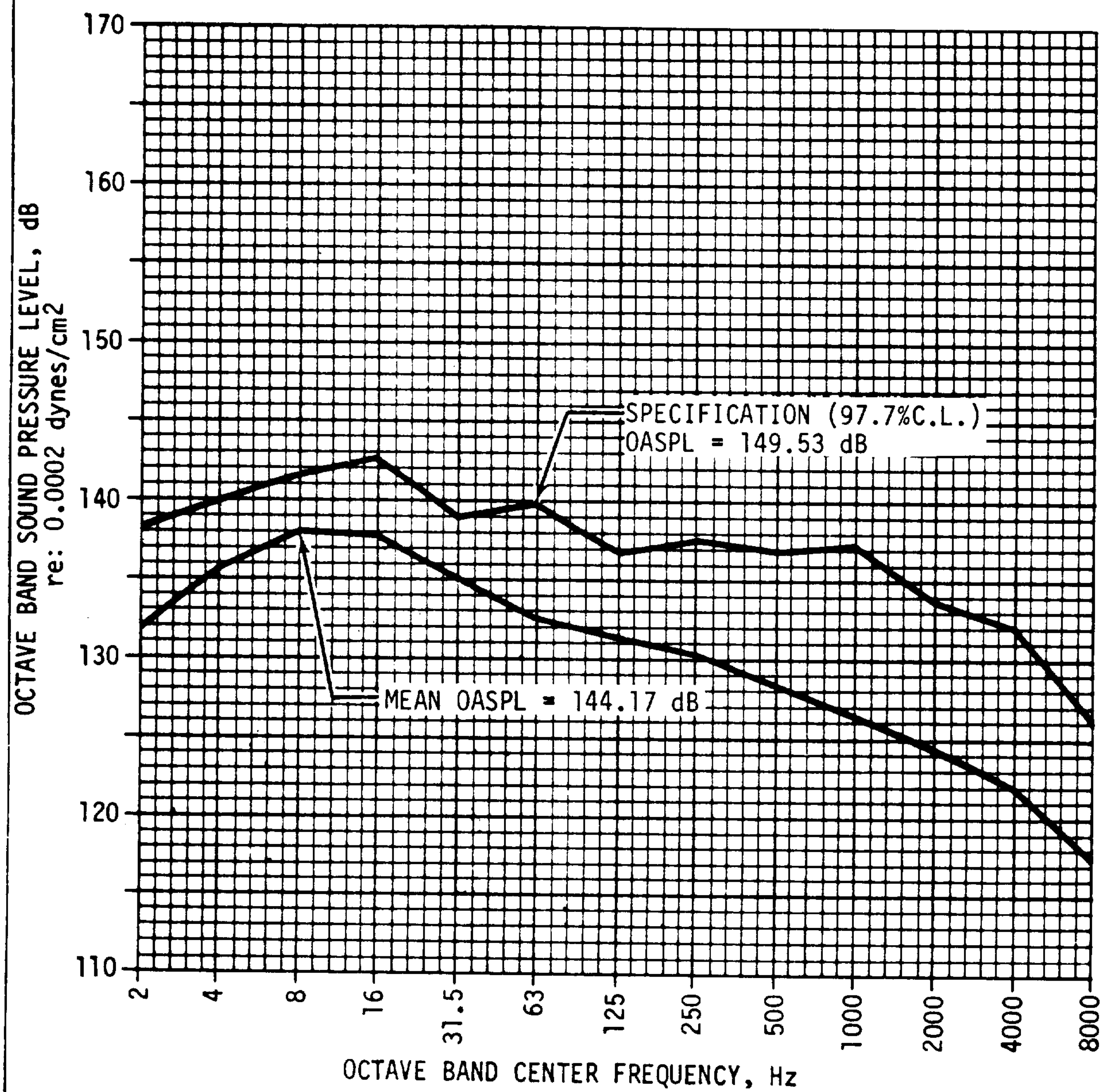


ACOUSTICAL SPECIFICATION
ZONE 1.2 AND 1.3
LIFT-OFF PEAK
MOBILE LAUNCHER PLATFORM COMPARTMENTS 36AB, 37A
AND 37B

Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50%C.L.)	Specification (97.7%C.L.)
2	141.2	152.2
4	141.8	151.5
8	143.9	154.2
16	145.1	154.0
31.5	145.8	155.1
63	146.9	155.7
125	147.0	155.5
250	144.7	156.0
500	143.8	153.1
1000	140.6	151.3
2000	135.0	146.1
4000	134.2	144.4
8000	131.0	140.9
OASPL	154.7	164.3

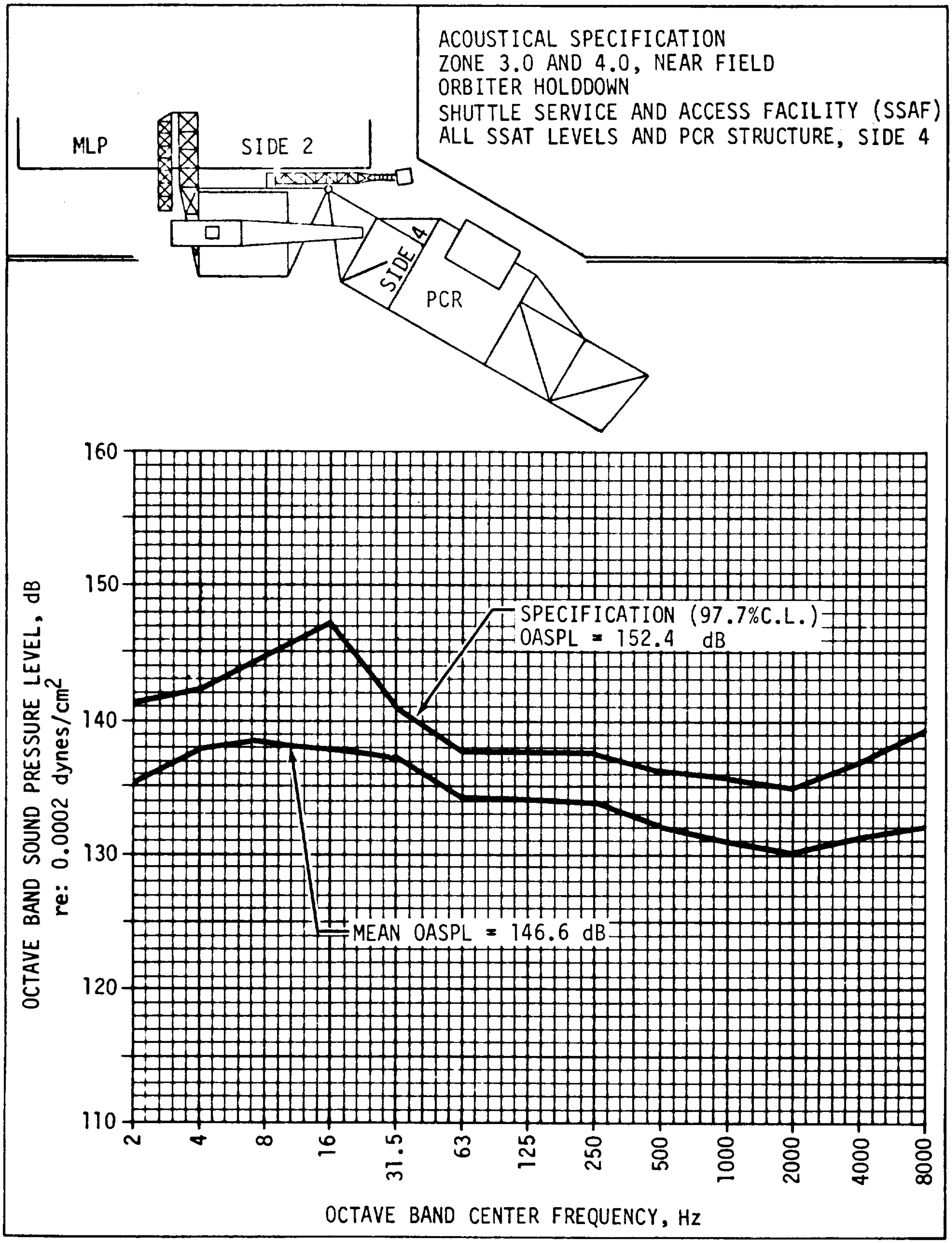


ACOUSTICAL SPECIFICATION
ZONE 1.2, 1.3, 2.2 AND 2.3
LIFT-OFF PEAK
MOBILE LAUNCHER PLATFORM COMPARTMENTS
EXCEPT VICINITY OF EXHAUST WELLS



ACOUSTICAL SPECIFICATION
ZONE 1.2, 1.3, 2.2 AND 2.3
LIFT-OFF PEAK
MOBILE LAUNCHER PLATFORM COMPARTMENTS
EXCEPT VICINITY OF EXHAUST WELLS

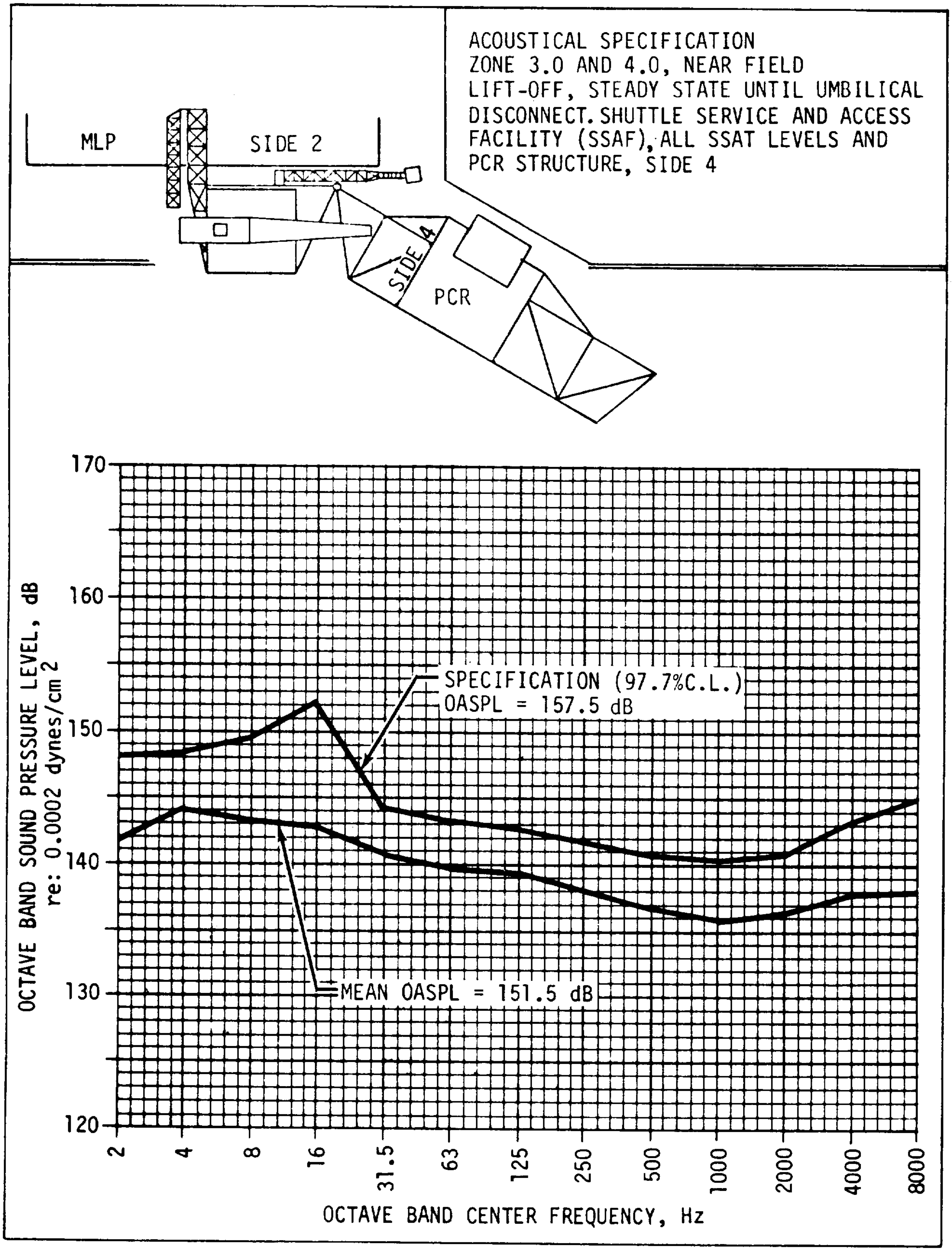
Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50%C.L.)	Specification (97.7%C.L.)
2	131.7	138.0
4	135.5	139.8
8	137.9	141.5
16	137.7	142.5
31.5	135.0	138.9
63	132.6	139.8
125	131.2	136.9
250	130.3	137.4
500	128.5	136.8
1000	126.5	137.2
2000	124.6	133.4
4000	122.1	132.0
8000	117.7	126.1
OASPL	144.17	149.53



ACOUSTICAL SPECIFICATION
ZONE 3.0 AND 4.0, NEAR FIELD
ORBITER HOLDDOWN
SHUTTLE SERVICE AND ACCESS FACILITY (SSAF)
ALL SSAT LEVELS AND PCR STRUCTURE, SIDE 4
MLP
SIDE 2
SIDE 4
PCR
SPECIFICATION (97.7%C.L.)
OASPL = 152.4 dB
MEAN OASPL = 146.6 dB
OCTAVE BAND SOUND PRESSURE LEVEL, dB
re: 0.0002 dynes/cm2
160
150
140
130
120
110
2
4
8
16
31.5
63
125
250
500
1000
2000
4000
8000
OCTAVE BAND CENTER FREQUENCY, Hz

ACOUSTICAL SPECIFICATION
ZONE 3.0 AND 4.0, NEAR FIELD
ORBITER HOLDDOWN
SHUTTLE SERVICE AND ACCESS FACILITY (SSAF)
ALL SSAT LEVELS AND PCR
STRUCTURE, SIDE 4

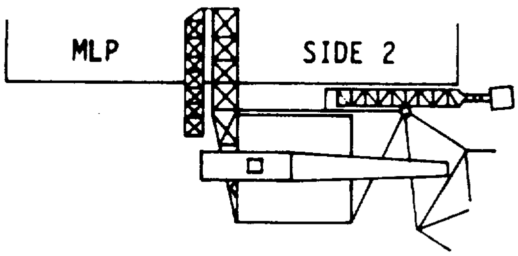
Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50%C.L.)	Specification (97.7%C.L.)
2	135.3	141.5
4	138.3	142.4
8	138.7	144.8
16	138.3	147.5
31.5	137.5	141.1
63	134.7	138.0
125	134.7	138.0
250	134.2	138.0
500	132.2	136.5
1000	131.2	136.0
2000	130.3	135.1
4000	131.4	137.2
8000	132.2	139.4
OASPL	146.60	152.44



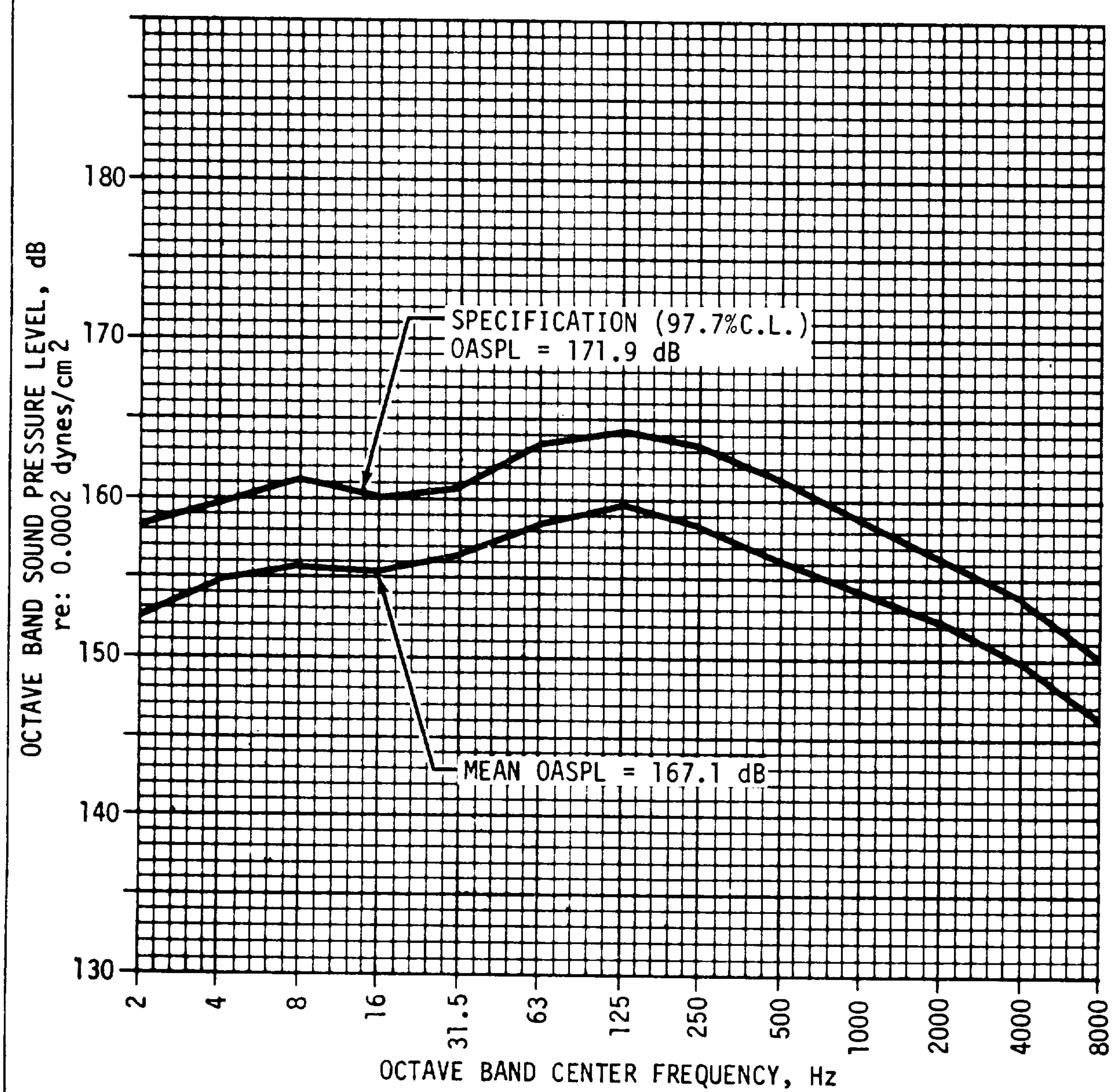
ACOUSTICAL SPECIFICATION
ZONE 3.0 AND 4.0, NEAR FIELD
LIFT-OFF, STEADY STATE UNTIL UMBILICAL DISCONNECT. SHUTTLE SERVICE AND ACCESS FACILITY (SSAF), ALL SSAT LEVELS AND PCR STRUCTURE, SIDE 4
MLP
SIDE 2
SIDE 4
PCR
SPECIFICATION (97.7%C.L.)
OASPL = 157.5 dB
MEAN OASPL = 151.5 dB
OCTAVE BAND SOUND PRESSURE LEVEL, dB
re: 0.0002 dynes/cm 2
170
160
150
140
130
120
2
4
8
16
31.5
63
125
250
500
1000
2000
4000
8000
OCTAVE BAND CENTER FREQUENCY, Hz

ACOUSTICAL SPECIFICATION
ZONE 3.0 AND 4.0, NEAR FIELD
LIFT-OFF, STEADY STATE UNTIL UMBILICAL DISCONNECT
SHUTTLE SERVICE AND ACCESS FACILITY (SSAF)
ALL SSAT LEVELS AND PCR STRUCTURE, SIDE 4

Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50%C.L.)	Specification (97.7%C.L.)
2	141.8	148.0
4	144.2	148.3
8	143.5	149.6
16	142.9	152.1
31.5	140.8	144.4
63	139.8	143.1
125	139.5	142.8
250	138.0	141.8
500	136.6	140.9
1000	135.6	140.4
2000	136.2	141.0
4000	137.6	143.4
8000	137.8	145.0
OASPL	151.5	157.5

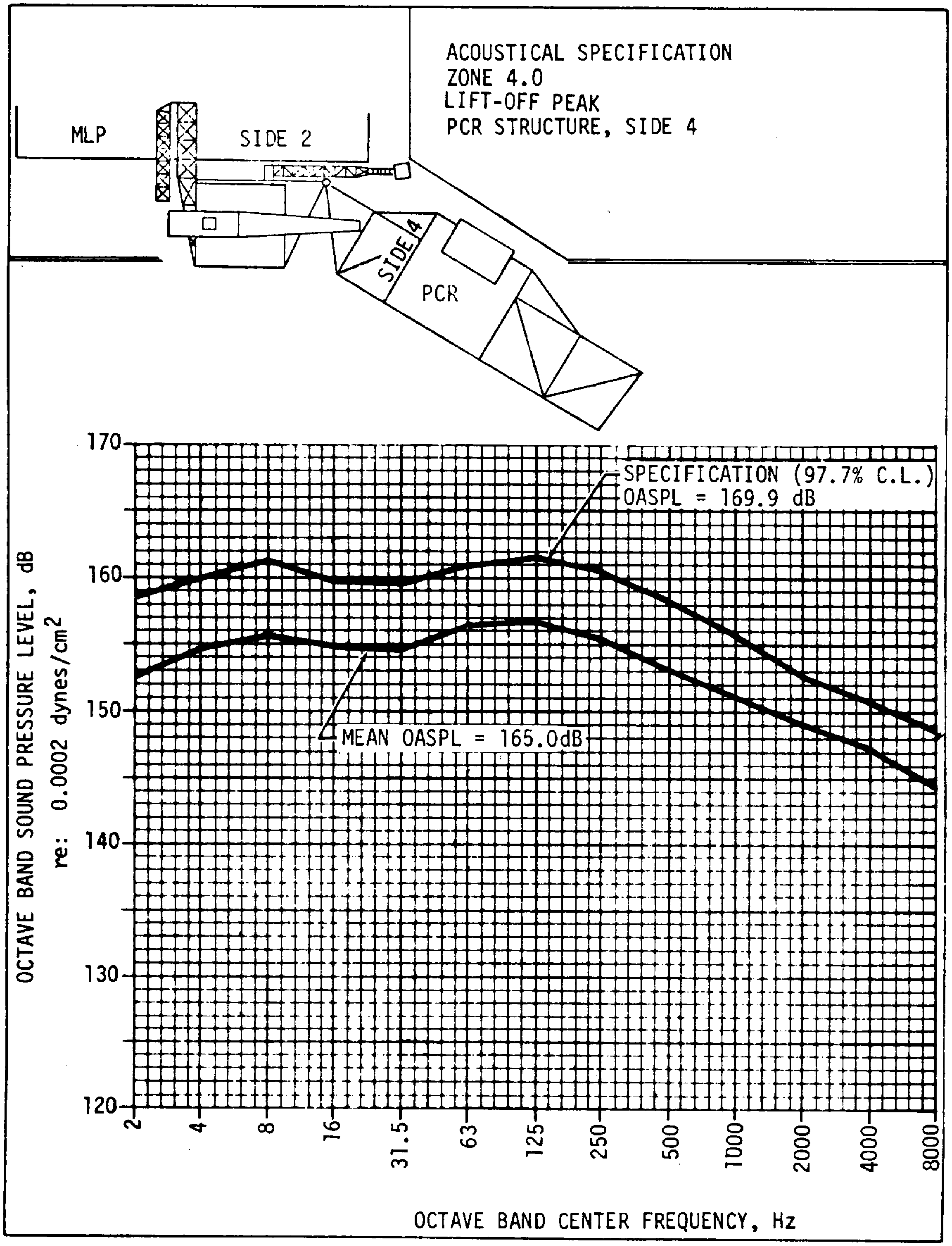


ACOUSTICAL SPECIFICATION
ZONE 3.0, NEAR FIELD
LIFT-OFF PEAK
SHUTTLE SERVICE AND ACCESS TOWER (SSAT)
ALL TOWER LEVELS



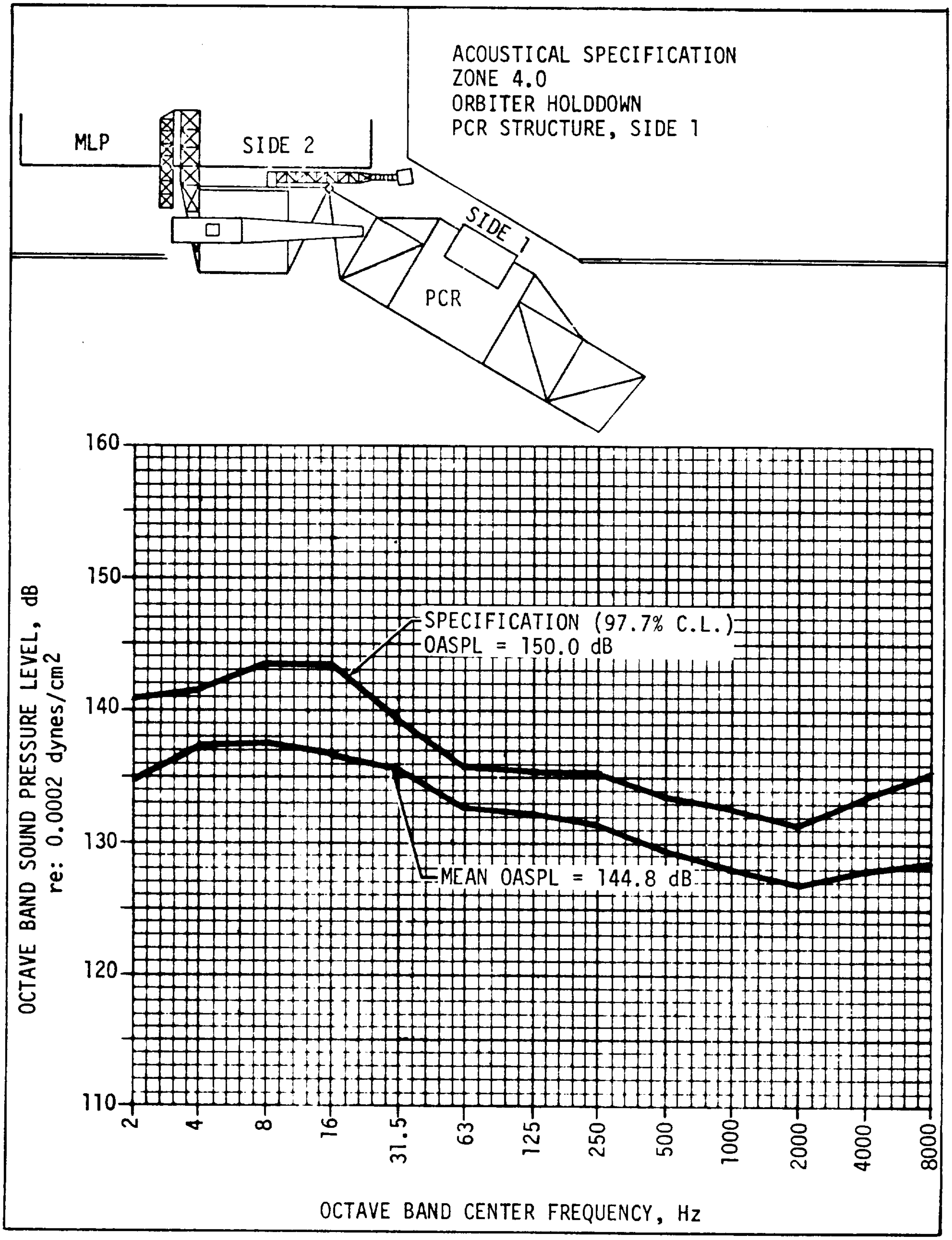
ACOUSTICAL SPECIFICATION
ZONE 3.0, NEAR FIELD
LIFT-OFF PEAK
SHUTTLE SERVICE AND ACCESS TOWER (SSAT)
ALL TOWER LEVELS

Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50%C.L.)	Specification (97.7%C.L.)
2	152.4	158.6
4	154.8	159.8
8	155.6	161.3
16	155.4	160.2
31.5	156.4	160.8
63	158.6	163.4
125	159.9	164.4
250	158.7	163.7
500	156.2	161.3
1000	154.4	159.0
2000	152.6	156.1
4000	150.3	154.0
8000	146.4	150.4
OASPL	167.1	171.9


ACOUSTICAL SPECIFICATION
ZONE 4.0
LIFT-OFF PEAK
PCR STRUCTURE, SIDE 4
MLP
SIDE 2
SIDE 4
PCR
SPECIFICATION (97.7% C.L.)
OASPL = 169.9 dB
MEAN OASPL = 165.0dB
OCTAVE BAND SOUND PRESSURE LEVEL, dB
re: 0.0002 dynes/cm2
170
160
150
140
130
120
2
4
8
16
31.5
63
125
250
500
1000
2000
4000
8000
OCTAVE BAND CENTER FREQUENCY, Hz

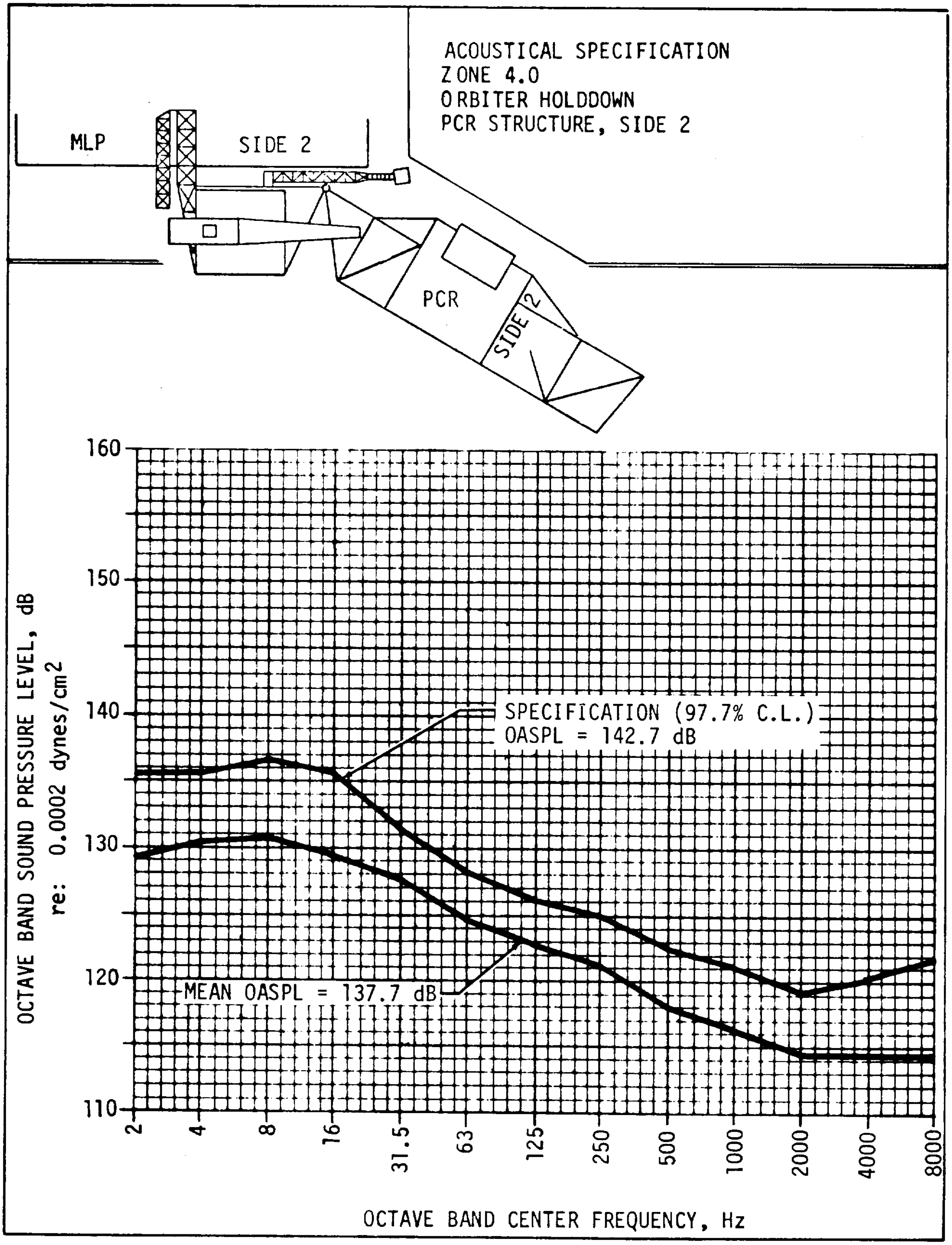
ACOUSTICAL SPECIFICATION
ZONE 4.0
LIFT-OFF PEAK
PCR STRUCTURE, SIDE 4

Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50%C.L.)	Specification (97.7%C.L.)
2	152.4	158.6
4	154.8	159.9
8	155.4	161.1
16	154.9	159.7
31.5	154.7	159.1
63	156.1	160.9
125	156.8	161.3
250	155.5	160.5
500	153.1	158.2
1000	151.1	155.7
2000	149.0	152.5
4000	147.1	150.8
8000	144.4	148.4
OASPL	165.0	169.9


ACOUSTICAL SPECIFICATION
ZONE 4.0
ORBITER HOLDDOWN
PCR STRUCTURE, SIDE 1
MLP
SIDE 2
SIDE 1
PCR
SPECIFICATION (97.7% C.L.)
OASPL = 150.0 dB
MEAN OASPL = 144.8 dB
OCTAVE BAND SOUND PRESSURE LEVEL, dB
re: 0.0002 dynes/cm2
160
150
140
130
120
110
2
4
8
16
31.5
63
125
250
500
1000
2000
4000
8000
OCTAVE BAND CENTER FREQUENCY, Hz

ACOUSTICAL SPECIFICATION
ZONE 4.0
ORBITER HOLDDOWN
PCR STRUCTURE, SIDE 1

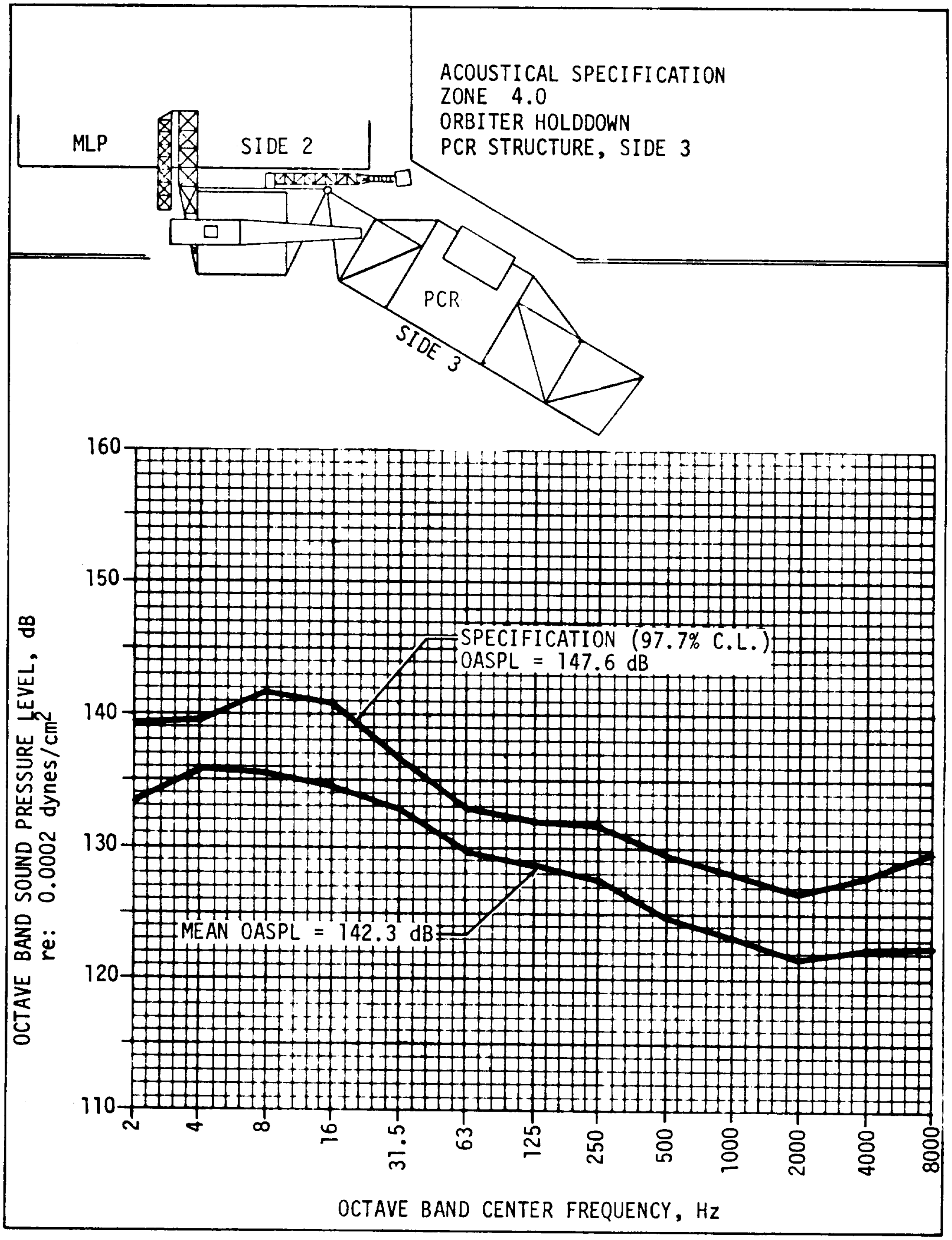
Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50% C.L.)	Specification (97.7% C.L.)
2	134.5	140.7
4	137.2	141.3
8	137.4	143.5
16	136.7	143.2
31.5	135.7	139.3
63	132.6	135.9
125	132.3	135.6
250	131.6	135.4
500	129.3	133.6
1000	128.0	132.8
2000	126.9	131.7
4000	127.7	133.5
8000	128.2	135.4
OASPL	144.8	150.0



ACOUSTICAL SPECIFICATION
ZONE 4.0
ORBITER HOLDDOWN
PCR STRUCTURE, SIDE 2
MLP
SIDE 2
PCR
SIDE 2
160
150
140
130
120
110
OCTAVE BAND SOUND PRESSURE LEVEL, dB
re: 0.0002 dynes/cm2
SPECIFICATION (97.7% C.L.)
OASPL = 142.7 dB
MEAN OASPL = 137.7 dB
2
4
8
16
31.5
63
125
250
500
1000
2000
4000
8000
OCTAVE BAND CENTER FREQUENCY, Hz

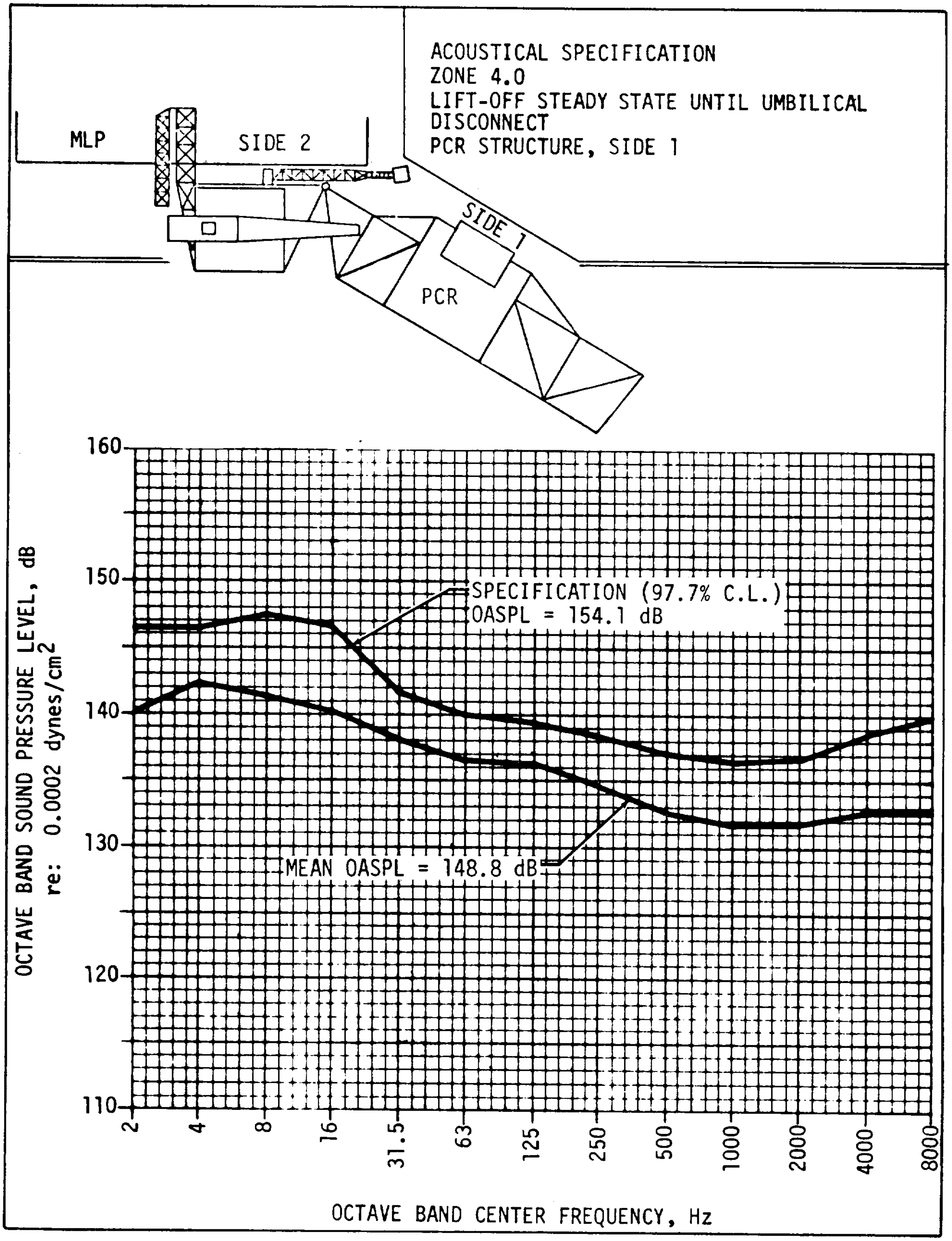
ACOUSTICAL SPECIFICATION
ZONE 4.0
ORBITER HOLDDOWN
PCR STRUCTURE, SIDE 2

Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50% C.L.)	Specification (97.7% C.L.)
2	129.2	135.4
4	131.3	135.4
8	130.7	136.8
16	129.3	135.8
31.5	127.5	131.1
63	124.7	128.0
125	122.7	126.0
250	121.2	125.0
500	118.2	122.5
1000	116.2	121.0
2000	114.3	119.1
4000	114.4	120.2
8000	114.2	121.4
OASPL	137.7	142.7


ACOUSTICAL SPECIFICATION
ZONE 4.0
ORBITER HOLDDOWN
PCR STRUCTURE, SIDE 3
MLP
SIDE 2
PCR
SIDE 3
SPECIFICATION (97.7% C.L.)
OASPL = 147.6 dB
MEAN OASPL = 142.3 dB
OCTAVE BAND SOUND PRESSURE LEVEL, dB
re: 0.0002 dynes/cm²
160
150
140
130
120
110
2
4
8
16
31.5
63
125
250
500
1000
2000
4000
8000
OCTAVE BAND CENTER FREQUENCY, Hz

ACOUSTICAL SPECIFICATION
ZONE 4.0
ORBITER HOLDDOWN
PCR STRUCTURE, SIDE 3

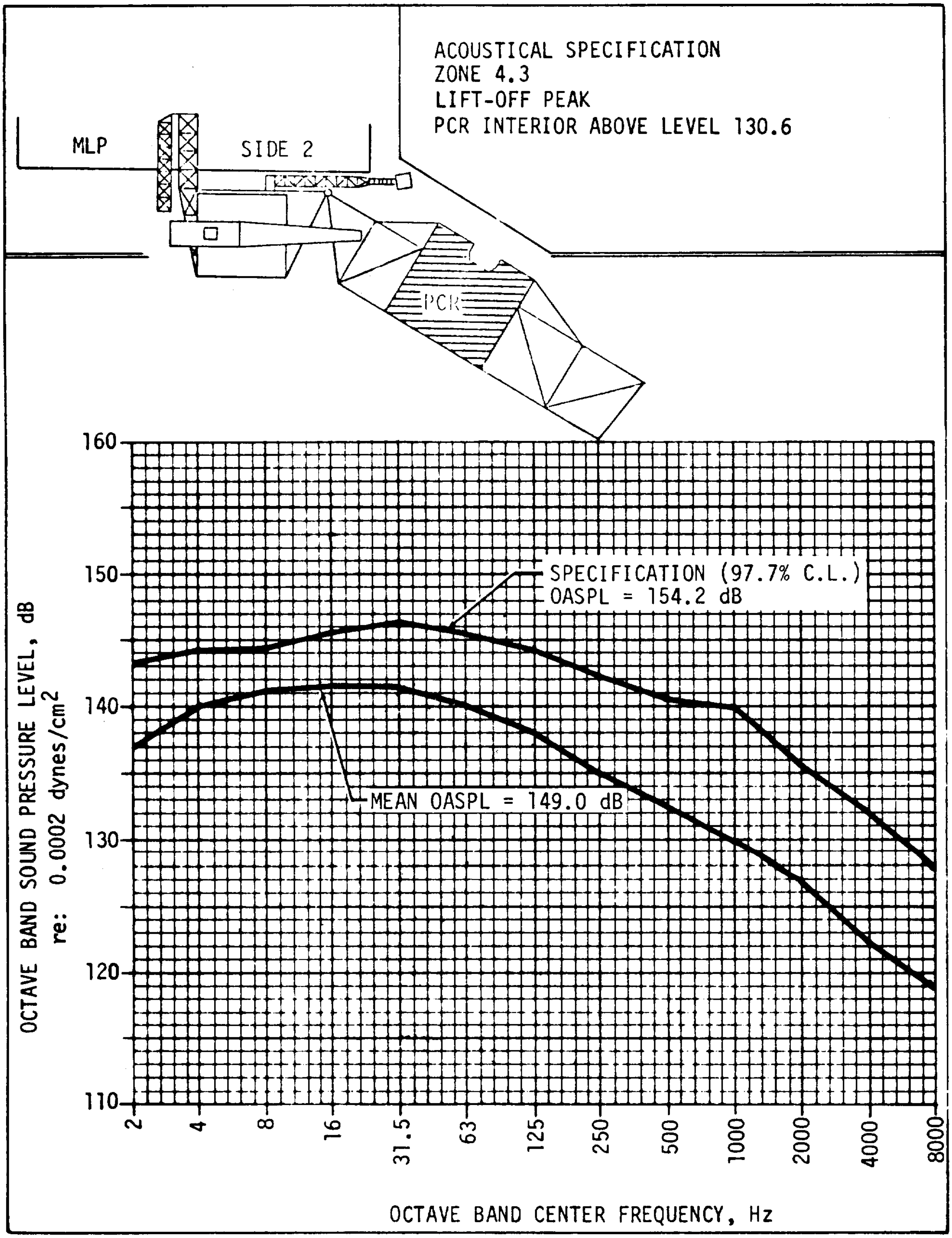
Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50% C.L.)	Specification (97.7% C.L.)
2	133.3	139.5
4	135.7	139.8
8	135.4	141.5
16	134.3	140.8
31.5	132.9	136.5
63	129.4	132.7
125	128.7	132.0
250	127.6	131.4
500	124.9	129.2
1000	123.2	128.0
2000	121.7	126.5
4000	122.1	127.9
8000	122.2	129.4
OASPL	142.3	147.6



ACOUSTICAL SPECIFICATION
ZONE 4.0
LIFT-OFF STEADY STATE UNTIL UMBILICAL DISCONNECT
PCR STRUCTURE, SIDE 1
MLP
SIDE 2
SIDE 1
PCR
SPECIFICATION (97.7% C.L.)
OASPL = 154.1 dB
MEAN OASPL = 148.8 dB
OCTAVE BAND SOUND PRESSURE LEVEL, dB
re: 0.0002 dynes/cm2
160
150
140
130
120
110
2
4
8
16
31.5
63
125
250
500
1000
2000
4000
8000
OCTAVE BAND CENTER FREQUENCY, Hz

ACOUSTICAL SPECIFICATION
ZONE 4.0
LIFT-OFF STEADY STATE UNTIL UMBILICAL DISCONNECT
PCR STRUCTURE, SIDE 1

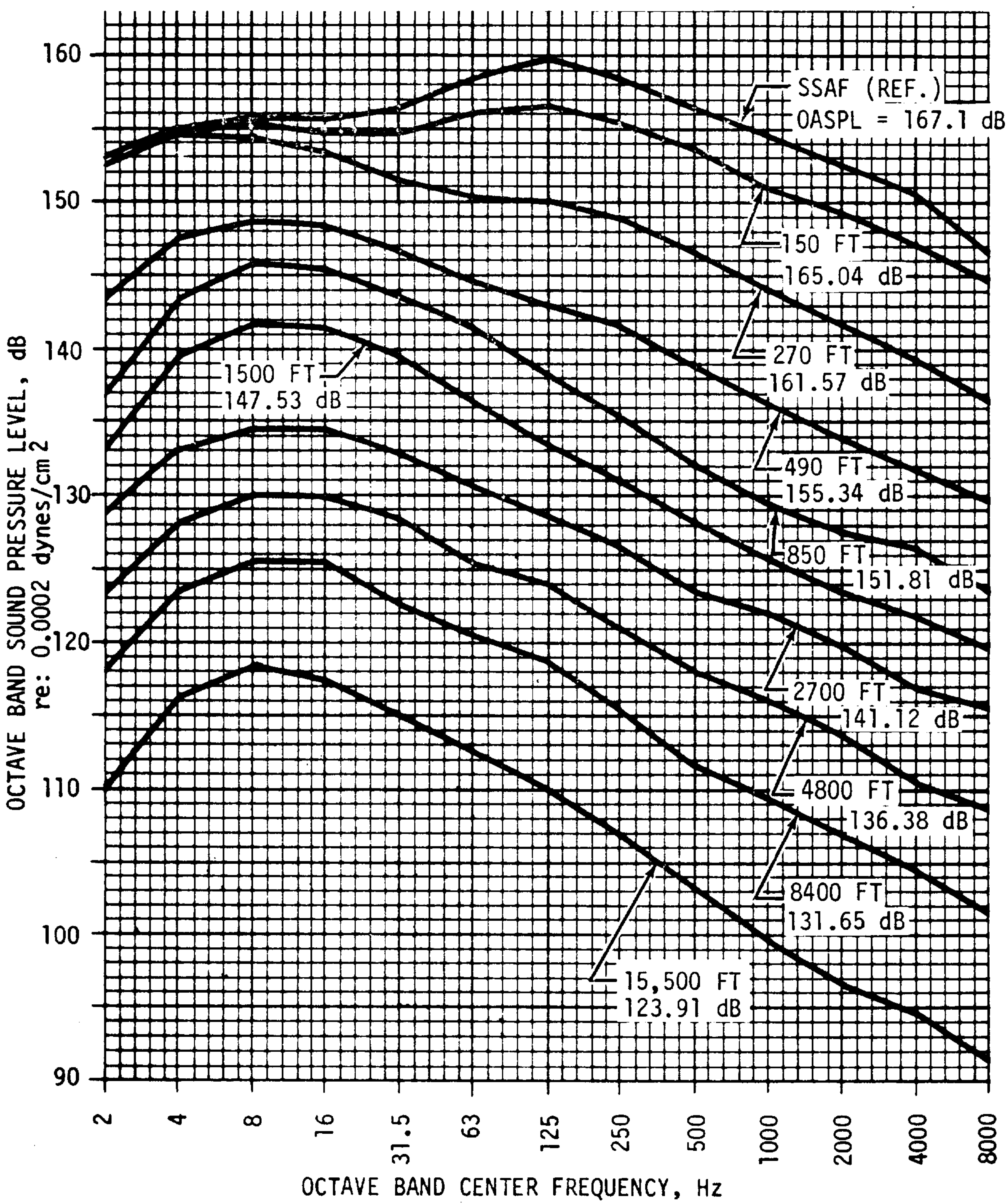
Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50% C.L.)	Specification (97.7% C.L.)
2	140.0	146.2
4	142.1	146.2
8	141.2	147.3
16	140.3	146.8
31.5	138.0	141.6
63	136.7	140.0
125	136.1	139.4
250	134.4	138.2
500	132.7	137.0
1000	131.4	136.2
2000	131.8	136.6
4000	132.9	138.7
8000	132.8	140.0
OASPL	148.8	154.1


ACOUSTICAL SPECIFICATION
ZONE 4.3
LIFT-OFF PEAK
PCR INTERIOR ABOVE LEVEL 130.6
MLP
SIDE 2
PCR
SPECIFICATION (97.7% C.L.)
OASPL = 154.2 dB
MEAN OASPL = 149.0 dB
OCTAVE BAND SOUND PRESSURE LEVEL, dB
re: 0.0002 dynes/cm2
160
150
140
130
120
110
2
4
8
16
31.5
63
125
250
500
1000
2000
4000
8000
OCTAVE BAND CENTER FREQUENCY, Hz

ACOUSTICAL SPECIFICATION
ZONE 4.3
LIFT-OFF PEAK
PCR INTERIOR ABOVE LEVEL 130.6

Octave Band Center Frequency Hz	Octave Band Sound Pressure Level Decibels (re: 0.0002 dynes/cm^2)	
	Mean (50% C.L.)	Specification (97.7% C.L.)
2	137.0	143.3
4	140.0	144.3
8	141.0	144.4
16	141.5	145.5
31.5	141.5	146.3
63	140.0	145.6
125	138.0	144.8
250	135.0	142.2
500	132.5	140.6
1000	130.0	138.9
2000	127.0	135.7
4000	123.5	132.0
8000	119.0	127.5
OASPL	149.0	154.2

FAR FIELD
PREDICTED AVERAGE SOUND PRESSURE LEVELS
(50 PERCENT CONFIDENCE LEVELS)



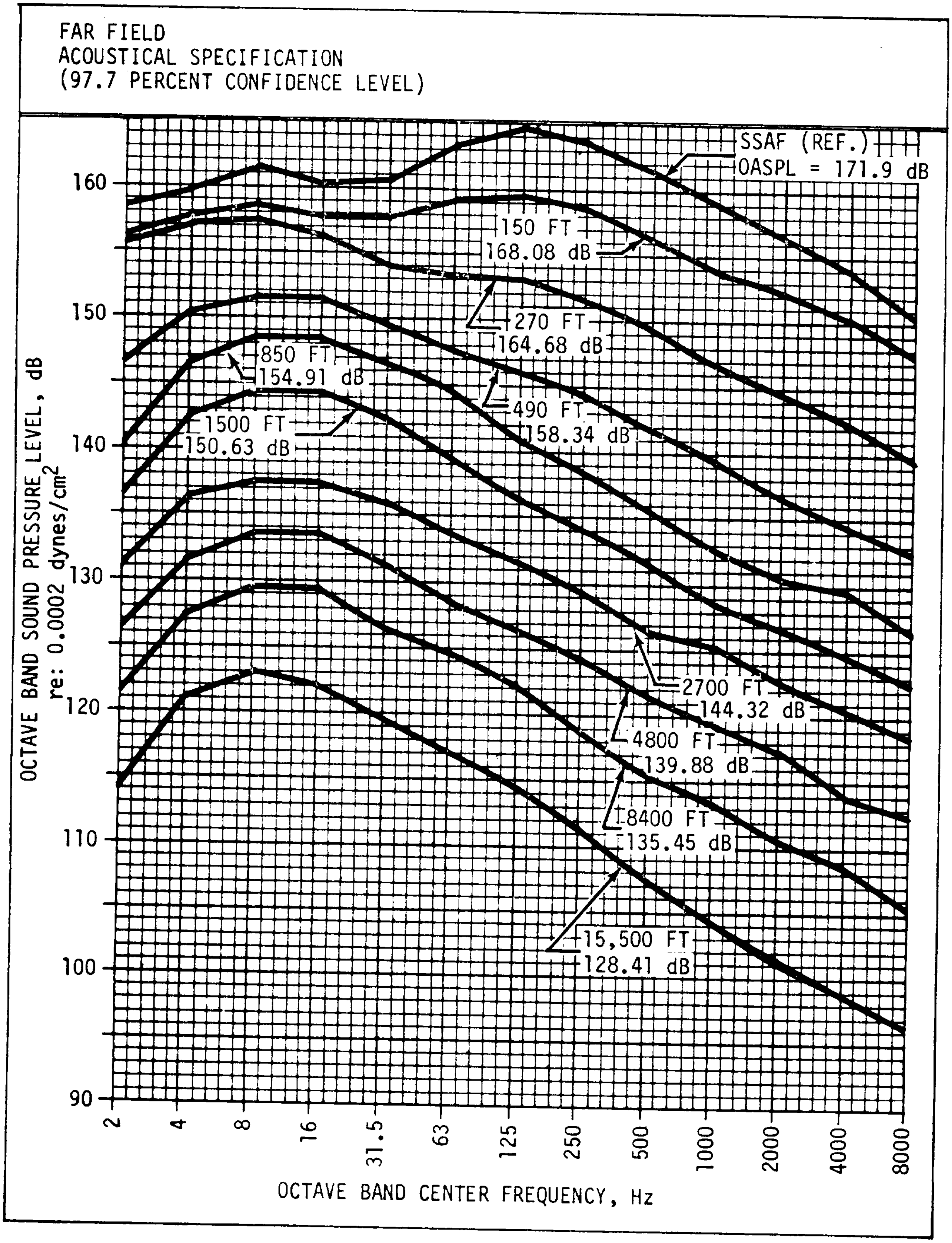
FAR FIELD
PREDICTED AVERAGE SOUND PRESSURE LEVELS, DECIBELS
(50 PERCENT CONFIDENCE LEVEL)

OCTAVE BAND SOUND PRESSURE LEVELS

FREQ	DISTANCE FROM CENTER OF MLP IN FEET								
Hz	150	270	490	850	1500	2700	4800	8400	15,500
2	152.4	152.4	143.5	137.0	133.1	128.5	123.3	117.9	109.5
4	154.8	154.4	147.5	143.5	139.5	133.0	128.4	123.6	116.4
8	155.4	154.5	148.8	145.8	141.7	134.5	130.0	125.5	118.5
16	154.9	153.2	148.2	145.7	141.4	134.4	129.9	125.6	117.4
31.5	154.9	151.0	146.4	143.6	139.2	132.8	128.2	122.8	115.0
63	156.0	150.2	144.5	141.2	136.2	130.5	125.2	121.0	112.5
125	156.7	150.0	142.9	137.8	133.1	128.3	123.1	118.4	109.9
250	155.7	148.7	141.4	135.2	130.9	126.3	120.9	115.1	106.9
500	153.3	146.3	138.7	132.1	128.0	123.1	118.0	111.6	103.0
1000	150.8	143.9	136.2	129.4	125.7	122.0	116.0	109.5	99.7
2000	149.2	141.6	133.9	127.6	123.7	119.7	113.6	106.8	96.8
4000	147.2	139.2	131.6	126.3	121.7	116.9	110.5	104.6	94.3
8000	144.7	136.5	129.4	123.4	119.3	115.3	108.8	101.5	91.6

OVERALL SOUND PRESSURE LEVELS

OASPL	165.04	161.57	155.34	151.81	147.53	141.12	136.38	131.65	123.91


FAR FIELD
ACOUSTICAL SPECIFICATION
(97.7 PERCENT CONFIDENCE LEVEL)
SSAF (REF.)
OASPL = 171.9 dB
150 FT
168.08 dB
270 FT
164.68 dB
850 FT
154.91 dB
490 FT
158.34 dB
1500 FT
150.63 dB
2700 FT
144.32 dB
4800 FT
139.88 dB
8400 FT
135.45 dB
15,500 FT
128.41 dB
OCTAVE BAND SOUND PRESSURE LEVEL, dB
re: 0.0002 dynes/cm2
160
150
140
130
120
110
100
90
2
4
8
16
31.5
63
125
250
500
1000
2000
4000
8000
OCTAVE BAND CENTER FREQUENCY, Hz

FAR FIELD
ACOUSTICAL SPECIFICATION, DECIBELS
(97.7 PERCENT CONFIDENCE LEVEL)

OCTAVE BAND SOUND PRESSURE LEVELS

FREQ Hz	DISTANCE FROM CENTER OF MLP IN FEET								
	150	270	490	850	1500	2700	4800	8400	15,500
2	156.1	155.5	146.5	140.1	136.2	131.7	126.8	121.7	114.0
4	157.8	157.4	150.5	146.6	142.6	136.2	131.9	127.4	120.9
8	158.4	157.5	151.8	148.9	144.8	137.7	133.5	129.3	123.0
16	157.9	156.2	151.2	148.8	144.5	137.6	134.4	129.4	121.9
31.5	157.9	154.0	149.4	146.7	142.3	136.0	131.7	126.6	119.5
63	159.0	153.2	147.5	144.3	139.3	133.7	128.7	124.8	117.0
125	159.7	153.0	145.9	140.9	136.2	131.5	126.6	122.2	114.4
250	158.7	151.7	144.4	138.3	134.0	129.5	124.4	118.9	111.4
500	156.3	149.3	141.7	135.2	131.1	126.3	121.5	115.4	107.5
1000	153.8	146.9	139.2	132.5	128.8	125.2	119.5	113.3	104.2
2000	152.2	144.6	136.9	130.7	126.8	122.9	117.1	110.6	101.3
4000	150.2	142.2	134.6	129.4	124.8	120.1	114.0	108.4	98.8
8000	147.7	139.5	132.4	126.5	122.4	118.5	112.3	105.3	96.1

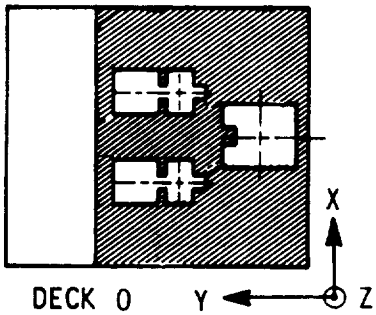
OVERALL SOUND PRESSURE LEVELS

OASPL	168.08	164.68	158.34	154.91	150.63	144.32	139.88	135.45	128.41

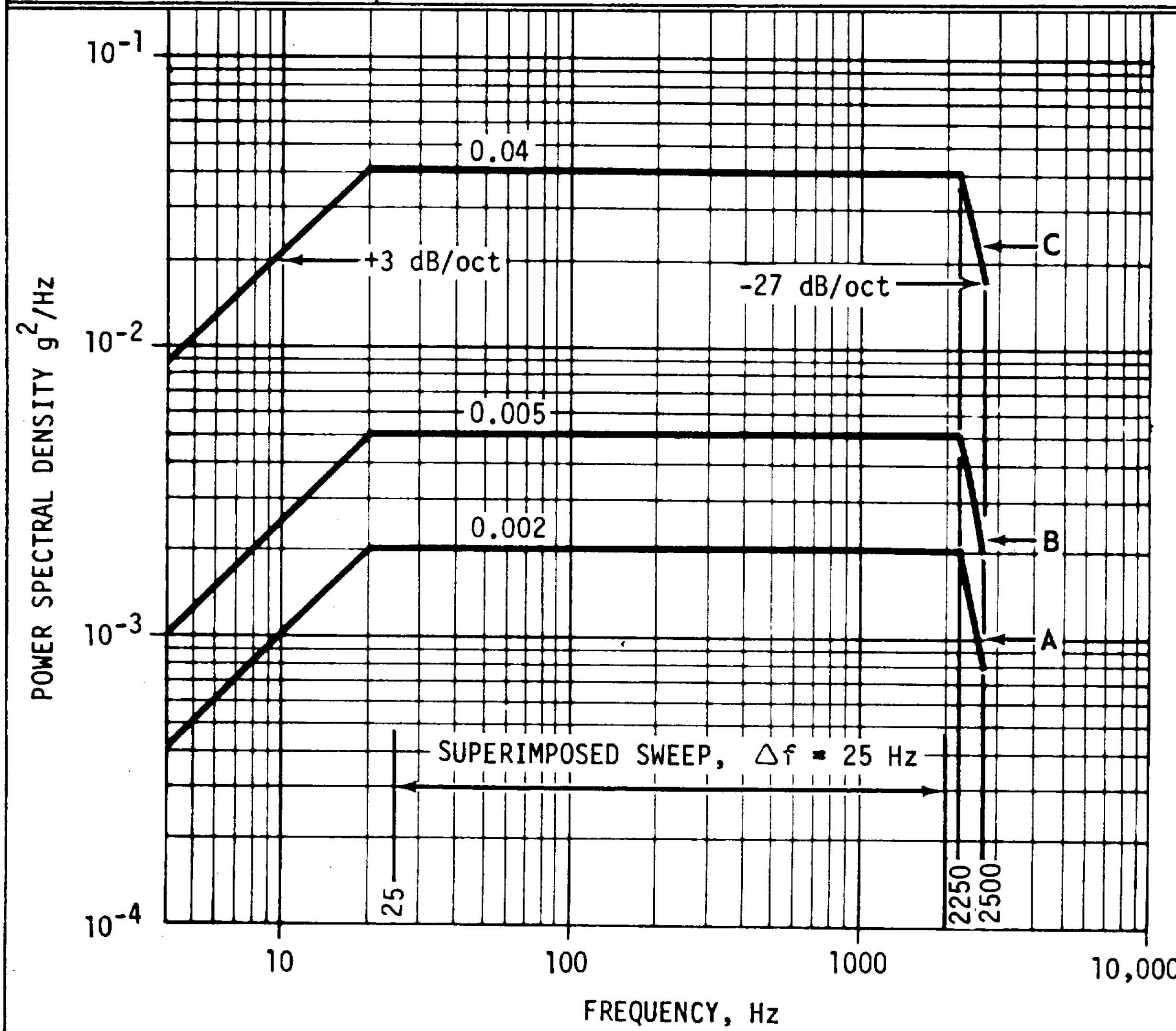
APPENDIX B

VIBRATION ENVIRONMENT SPECIFICATIONS

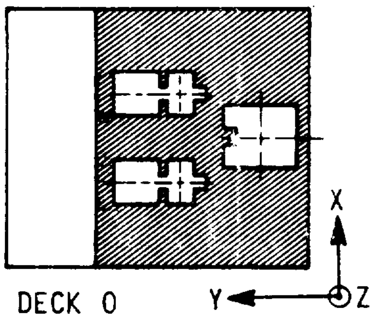
Vibration Specifications	Page
GSE and Components Mounted on MLP Floors	B-2
GSE and Components Mounted on MLP Walls	B-48
GSE and Components Mounted on the SSAT	B-96
GSE and Components Mounted on the Rotary Bridge and in the PCR	B-130



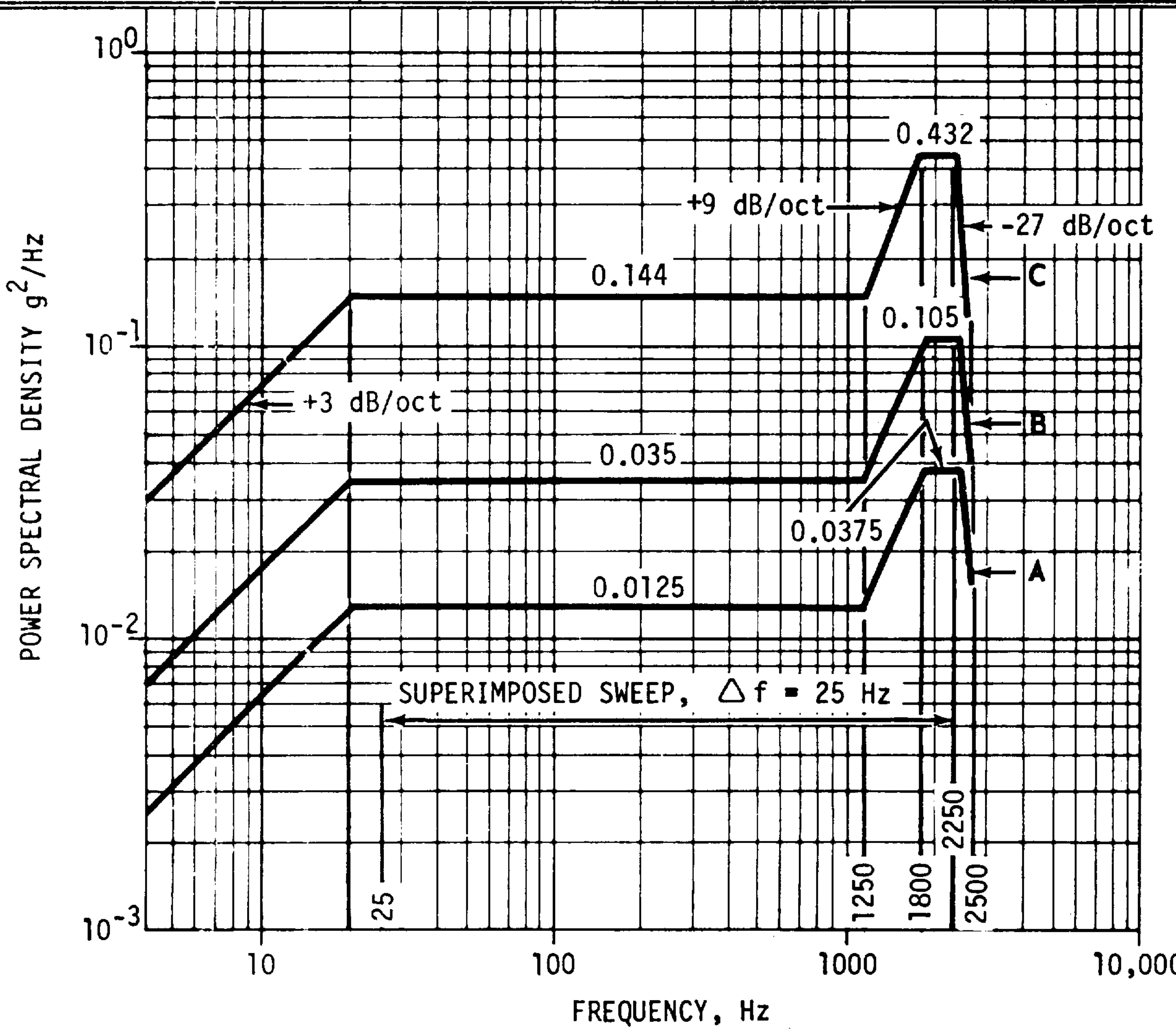
RANDOM VIBRATION ENVIRONMENT
ZONES 1.1.1.1, 1.1.1.2, 1.1.1.3, 1.1.1.4,
AND 1.1.2.1.
LAUNCHER DECK
X - DIRECTION



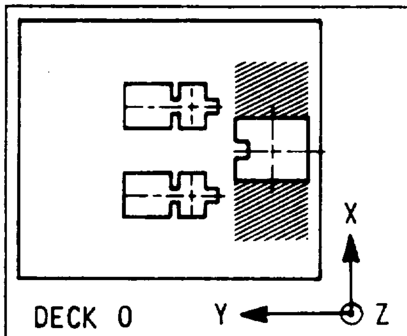
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	2.7
B	Lift-off Steady State Until Umbilical Disconnect	0.1	3.8
C	Lift-off Peak	0.25	10.1



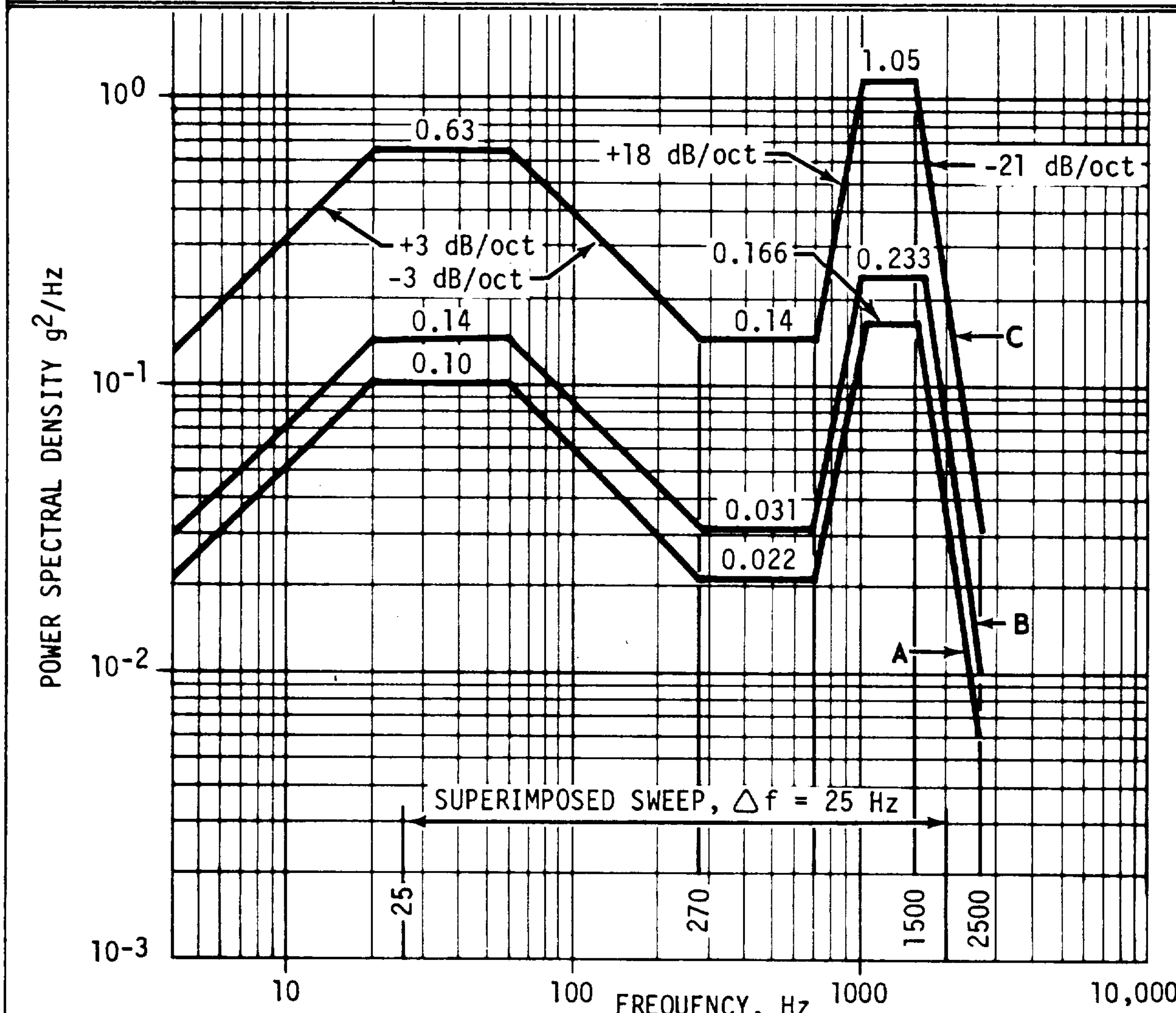
RANDOM VIBRATION ENVIRONMENT
ZONES 1.1.1.1, 1.1.1.2, 1.1.1.3, 1.1.1.4,
AND 1.1.2.1
LAUNCHER DECK
Y - DIRECTION



Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	7.4
B	Lift-off Steady State Until Umbilical Disconnect	0.1	12.1
C	Lift-off Peak	0.4	24.6

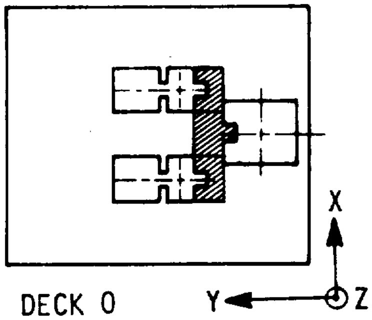


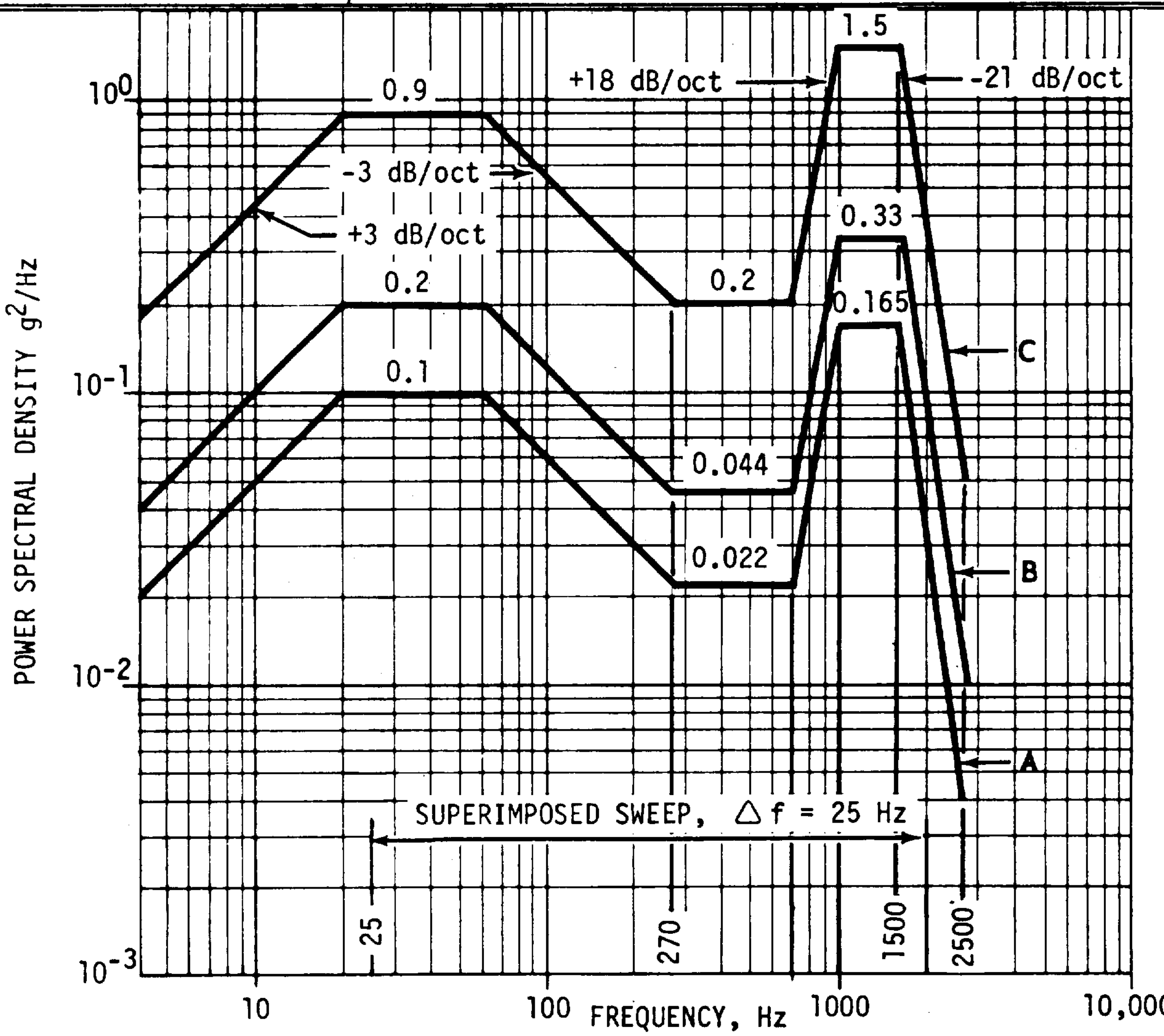
RANDOM VIBRATION ENVIRONMENT
ZONE 1.1.1.1
LAUNCHER DECK. CEILING OF COMPARTMENTS
33A, 34A, 43A, and 44A
Z - DIRECTION



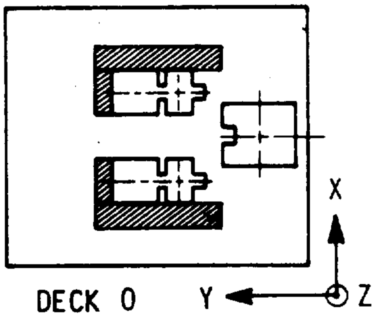
Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.2	13.2
B	Liftoff Steady State Until Umbilical Disconnect	0.2	15.5
C	Liftoff Peak	1.0	33.0

RANDOM VIBRATION ENVIRONMENT
ZONE 1.1.1.2
LAUNCHER DECK. CEILING OF COMPARTMENTS
35AB, 38AB AND 39AB
Z - DIRECTION

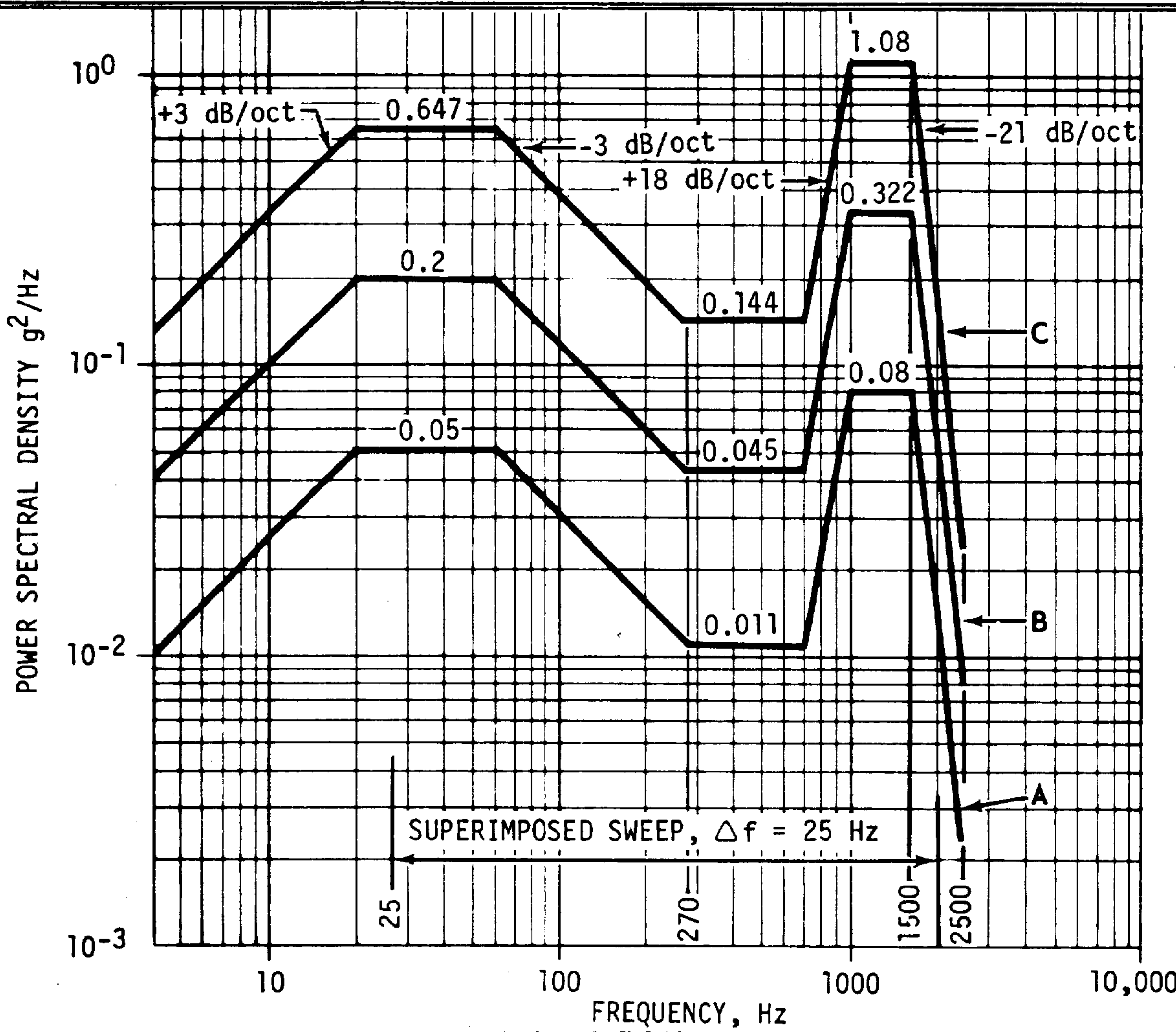




Sym.	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.2	13.2
B	Lift-off Steady State Until Umbilical Disconnect	0.2	18.5
C	Lift-off Peak	1.0	39.3

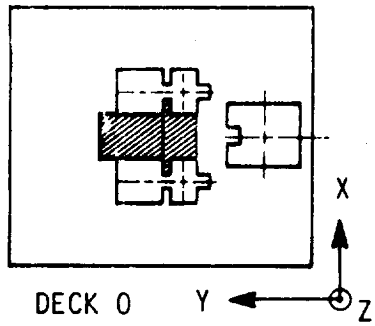


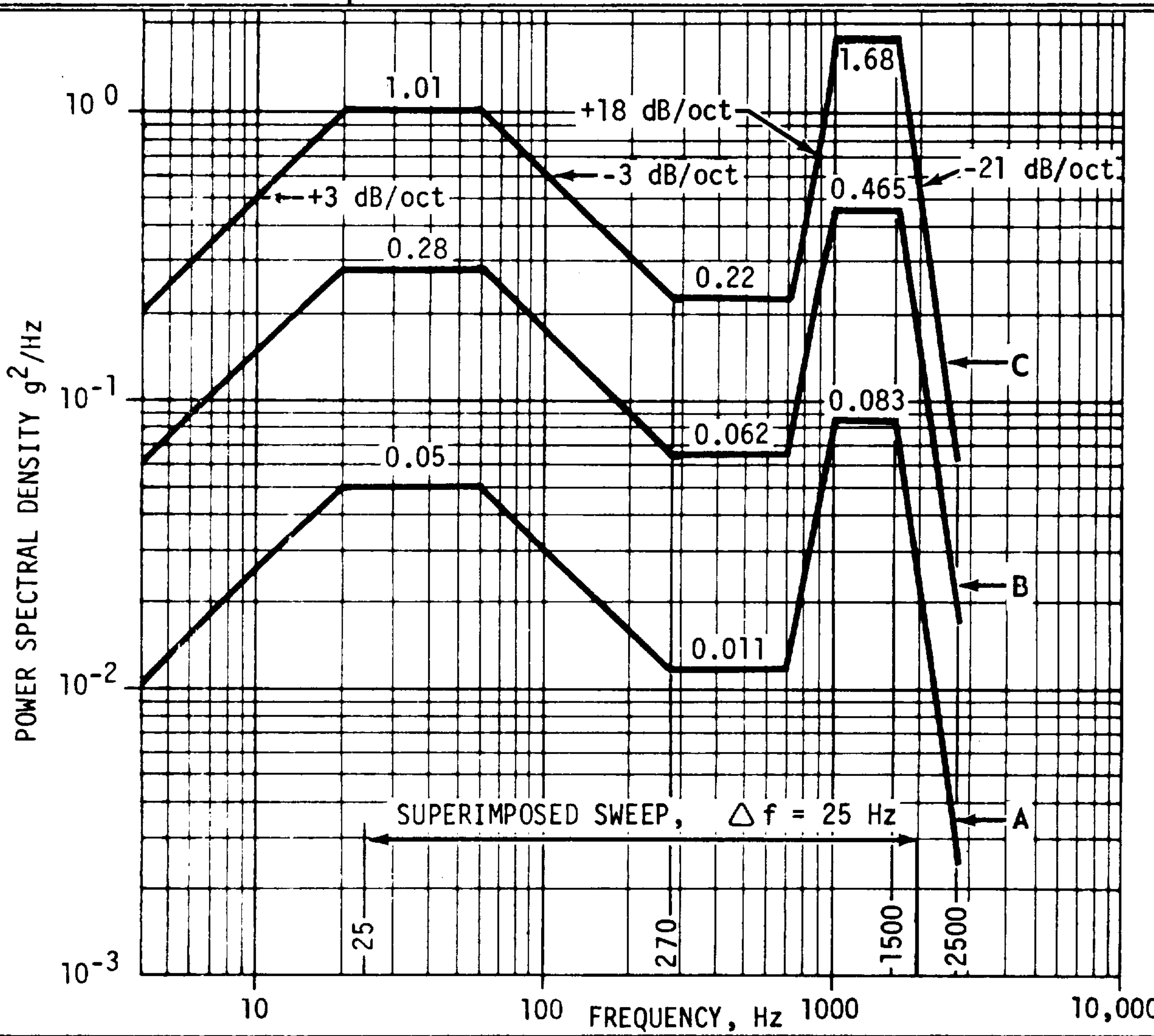
RANDOM VIBRATION ENVIRONMENT
ZONE 1.1.1.3
LAUNCHER DECK. CEILING OF COMPARTMENTS
30AB, 31A, 32AB, 40AB, 41A, 42AB, 46AB AND 47AB
Z - DIRECTION



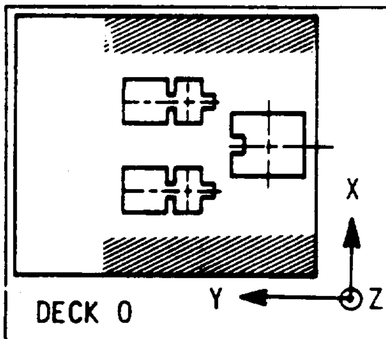
Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.2	9.4
B	Lift-off Steady State Until Umbilical Disconnect	0.2	18.5
C	Lift-off Peak	1.0	33.4

RANDOM VIBRATION ENVIRONMENT
ZONE 1.1.1.4
LAUNCHER DECK. CEILING OF COMPARTMENTS
36AB, AND 37A
Z - DIRECTION

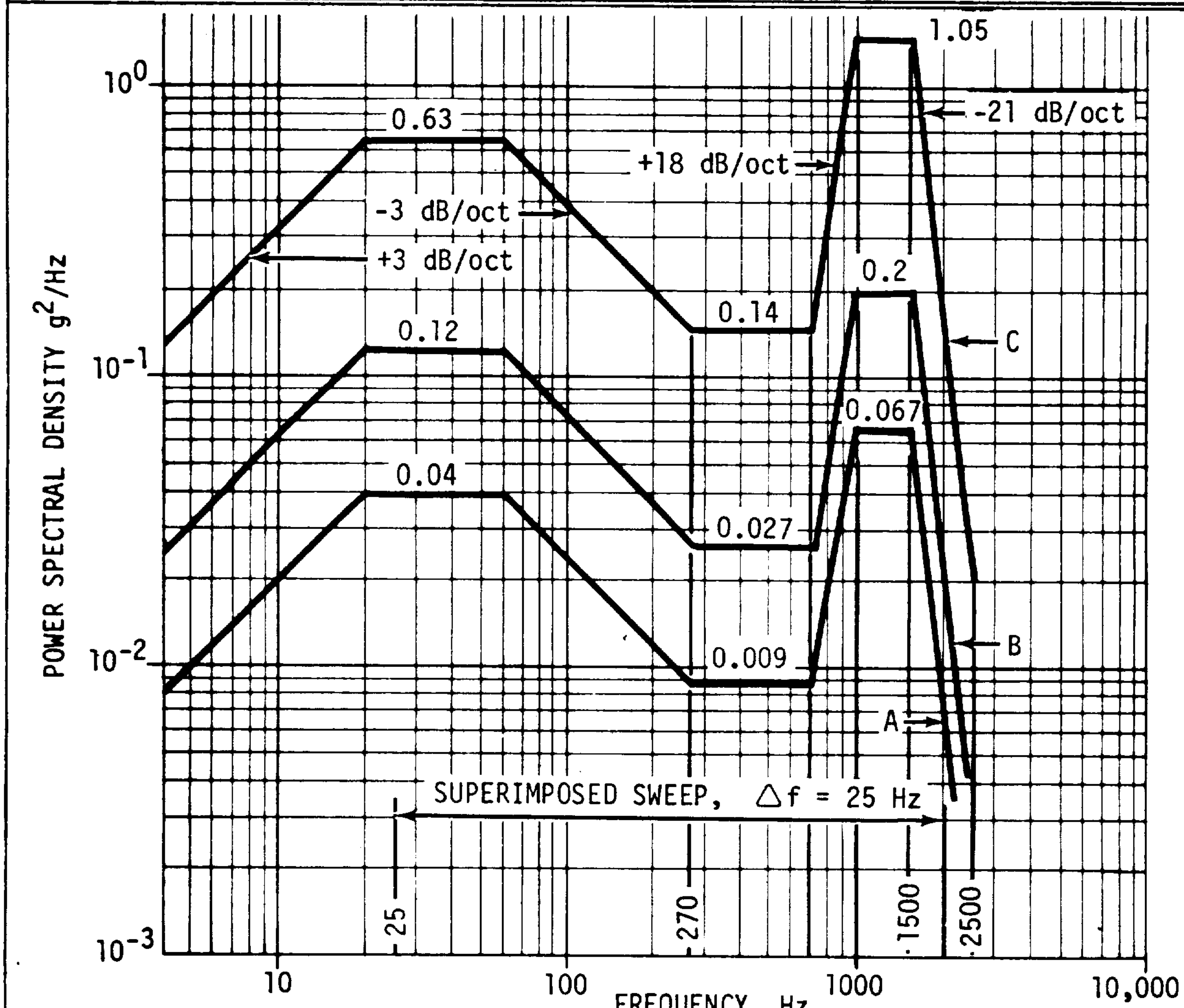




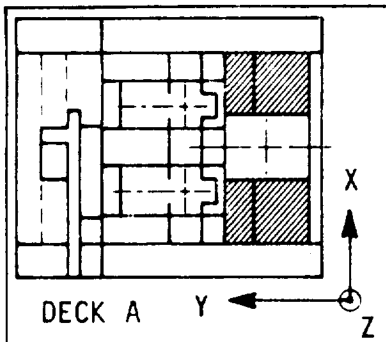
Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.2	9.4
B	Lift-off Steady State Until Umbilical Disconnect	0.2	21.8
C	Lift-off Peak	1.0	41.5



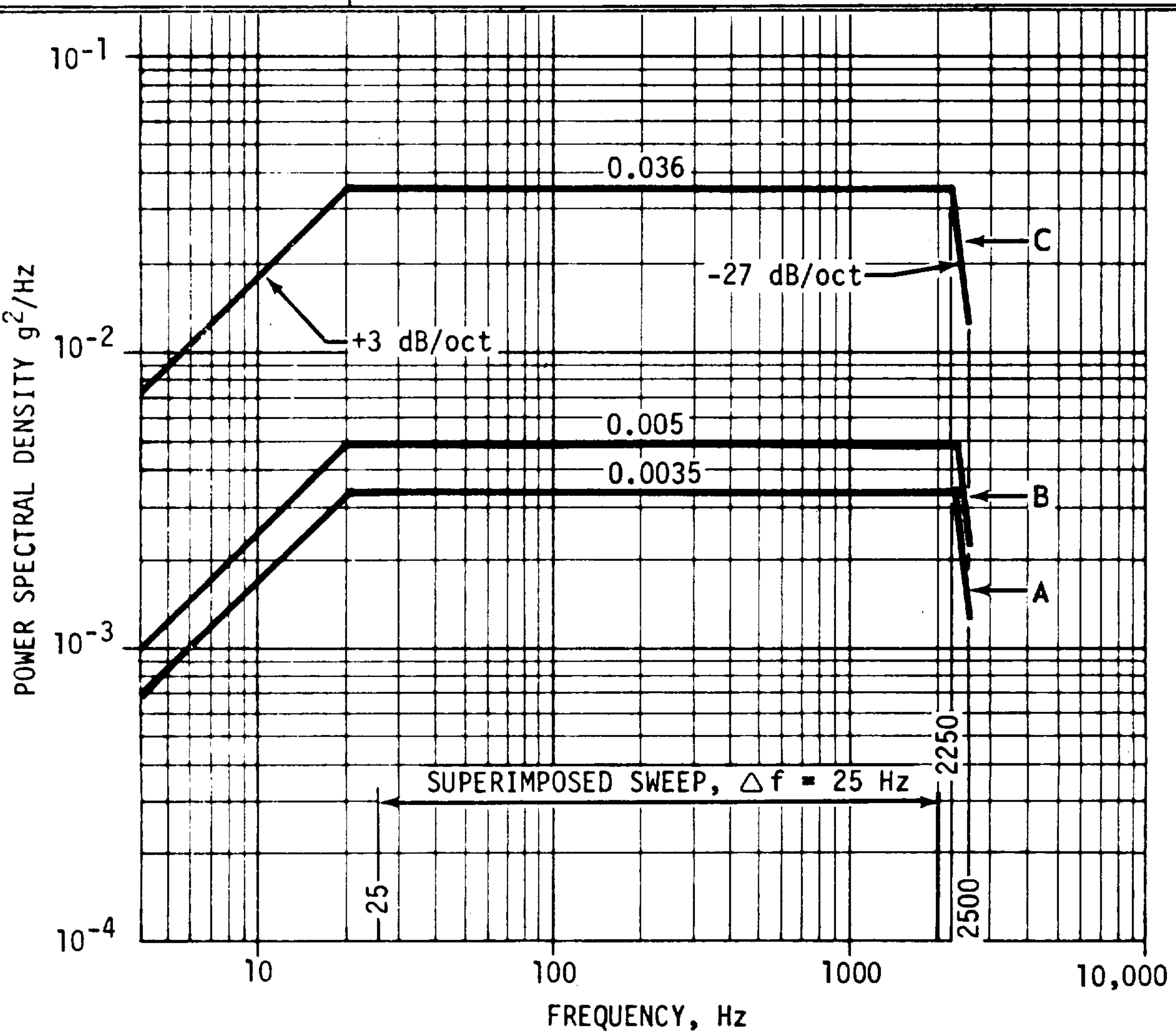
RANDOM VIBRATION ENVIRONMENT
ZONE 1.1.2.1
LAUNCHER DECK. CEILING OF COMPARTMENTS
2A AND 16A
Z - DIRECTION



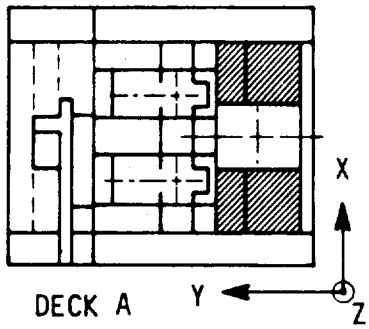
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.2	8.5
B	Lift-off Steady State Until Umbilical Disconnect	0.2	14.4
C	Lift-off Peak	1.0	33.0



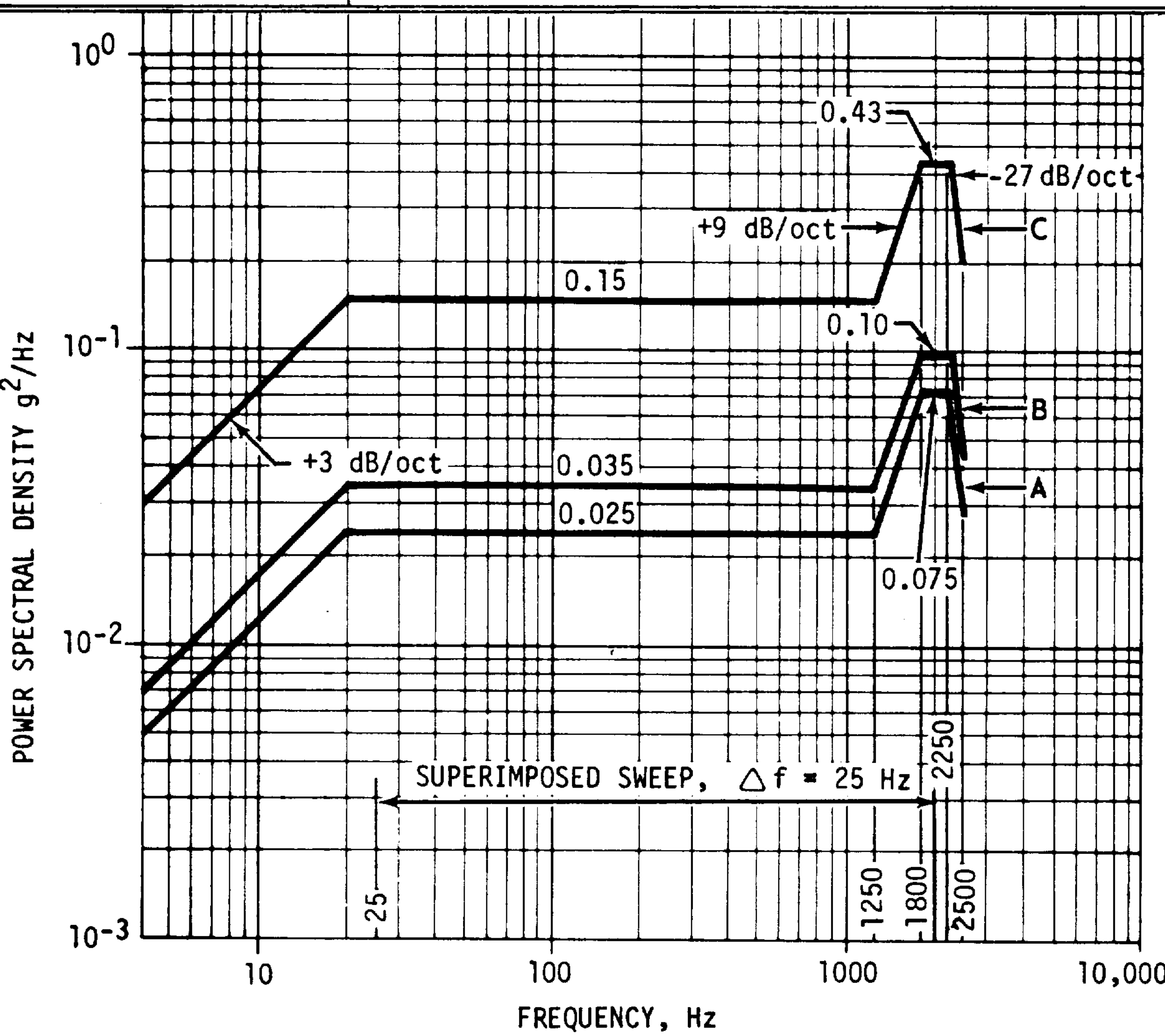
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.1.1
FLOOR BEAMS SUPPORTING GRATING, COMPARTMENTS 33A, 34A, 43A AND 44A
X-DIRECTION



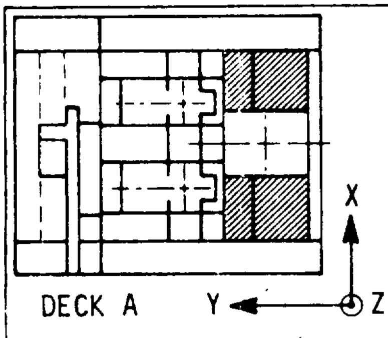
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	3.1
B	Lift-off Steady State Until Umbilical Disconnect	0.07	3.7
C	Lift-off Peak	0.18	9.5



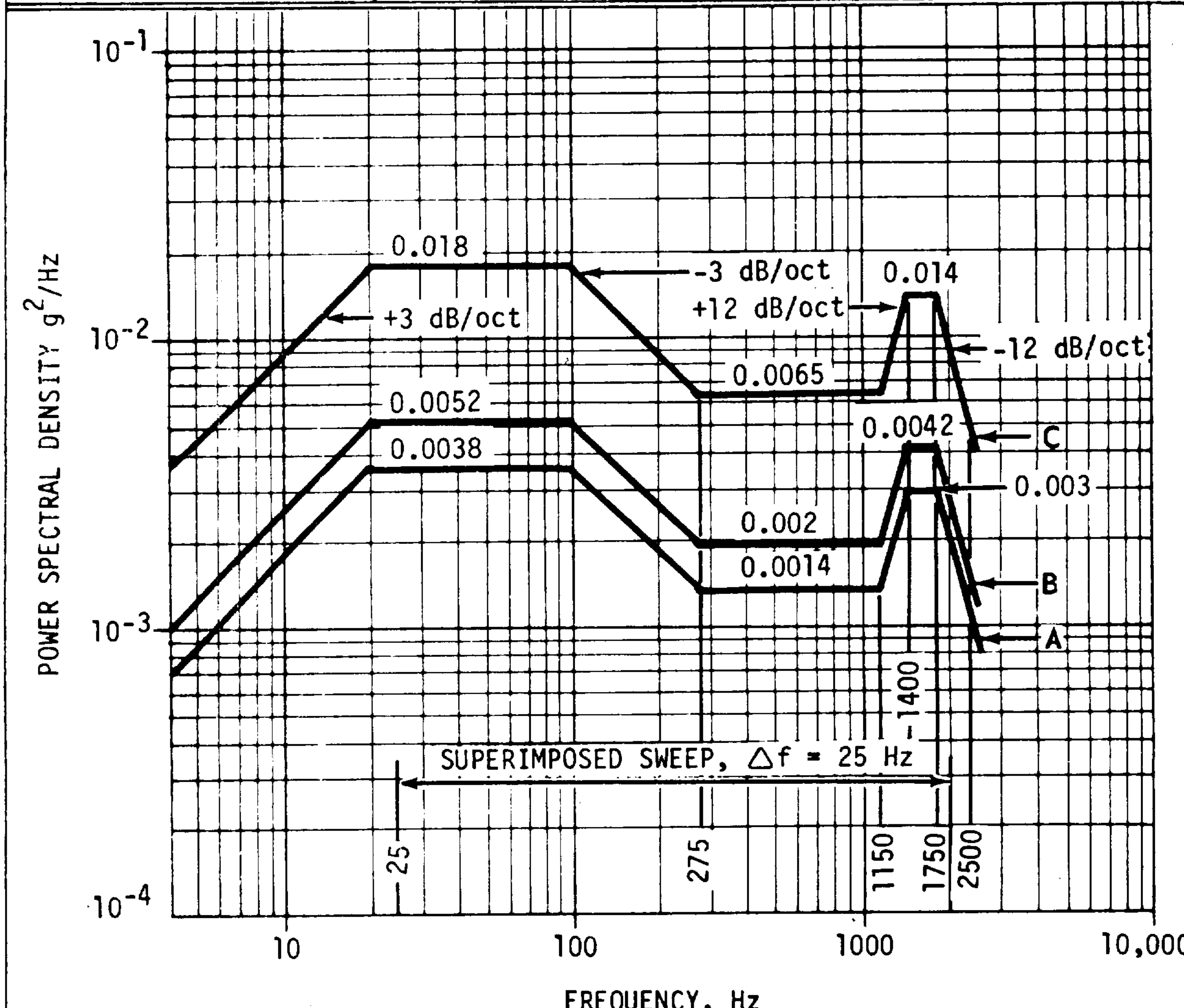
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.1.1
FLOOR BEAMS SUPPORTING GRATING, COMPARTMENTS 33A, 34A, 43A AND 44A
Y-DIRECTION



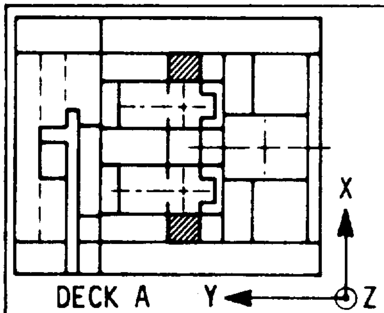
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	10.2
B	Lift-off Steady State Until Umbilical Disconnect	0.07	12.1
C	Lift-off Peak	0.3	24.6



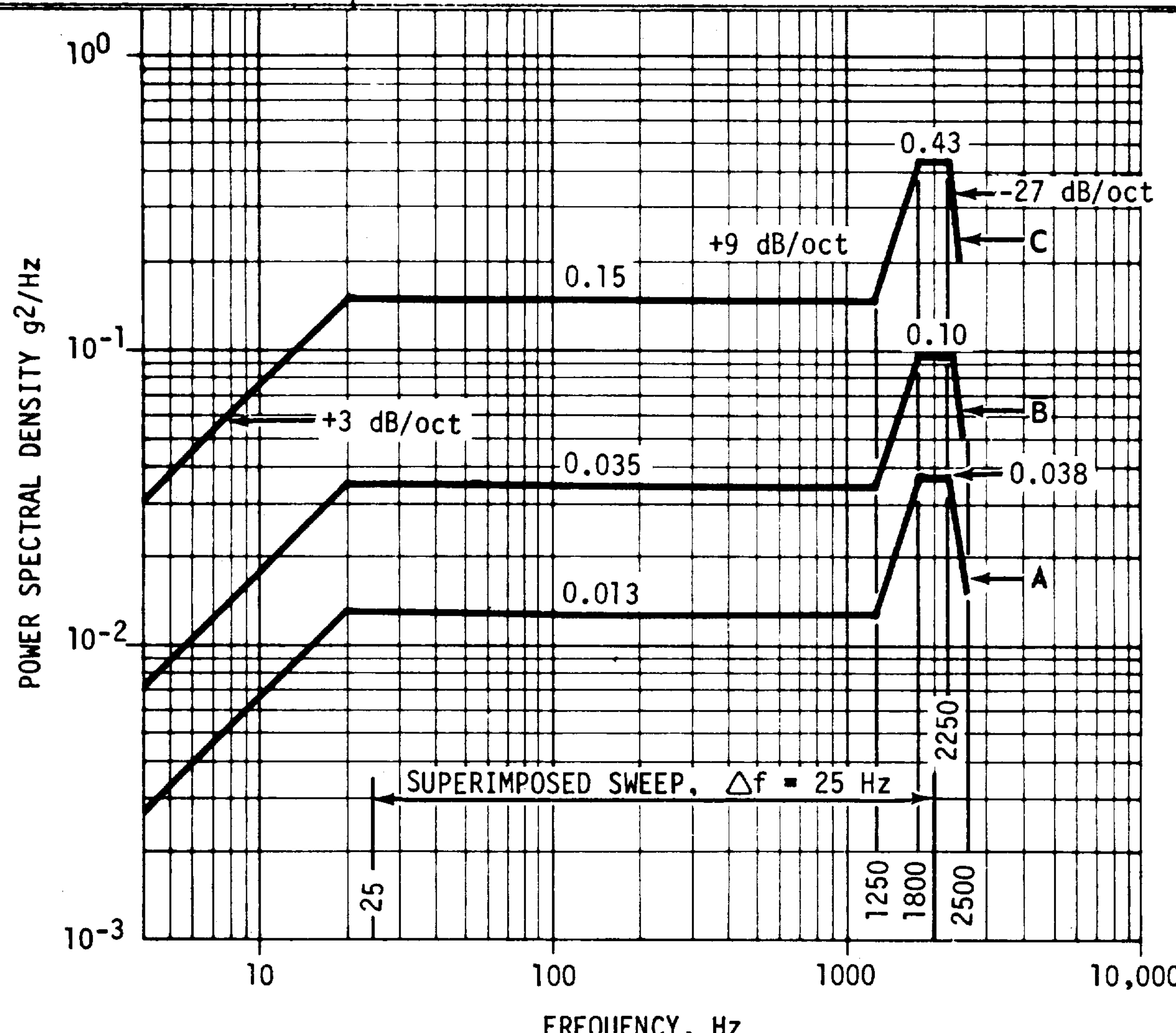
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.1.1
FLOOR BEAMS SUPPORTING GRATING, COMPARTMENTS
33A, 34A, 43A AND 44A
Z-DIRECTION



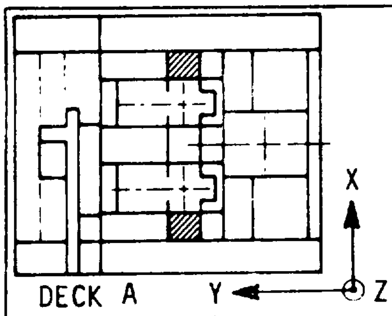
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	2.3
B	Lift-off Steady State Until Umbilical Disconnect	0.03	2.7
C	Lift-off Peak	0.04	4.8



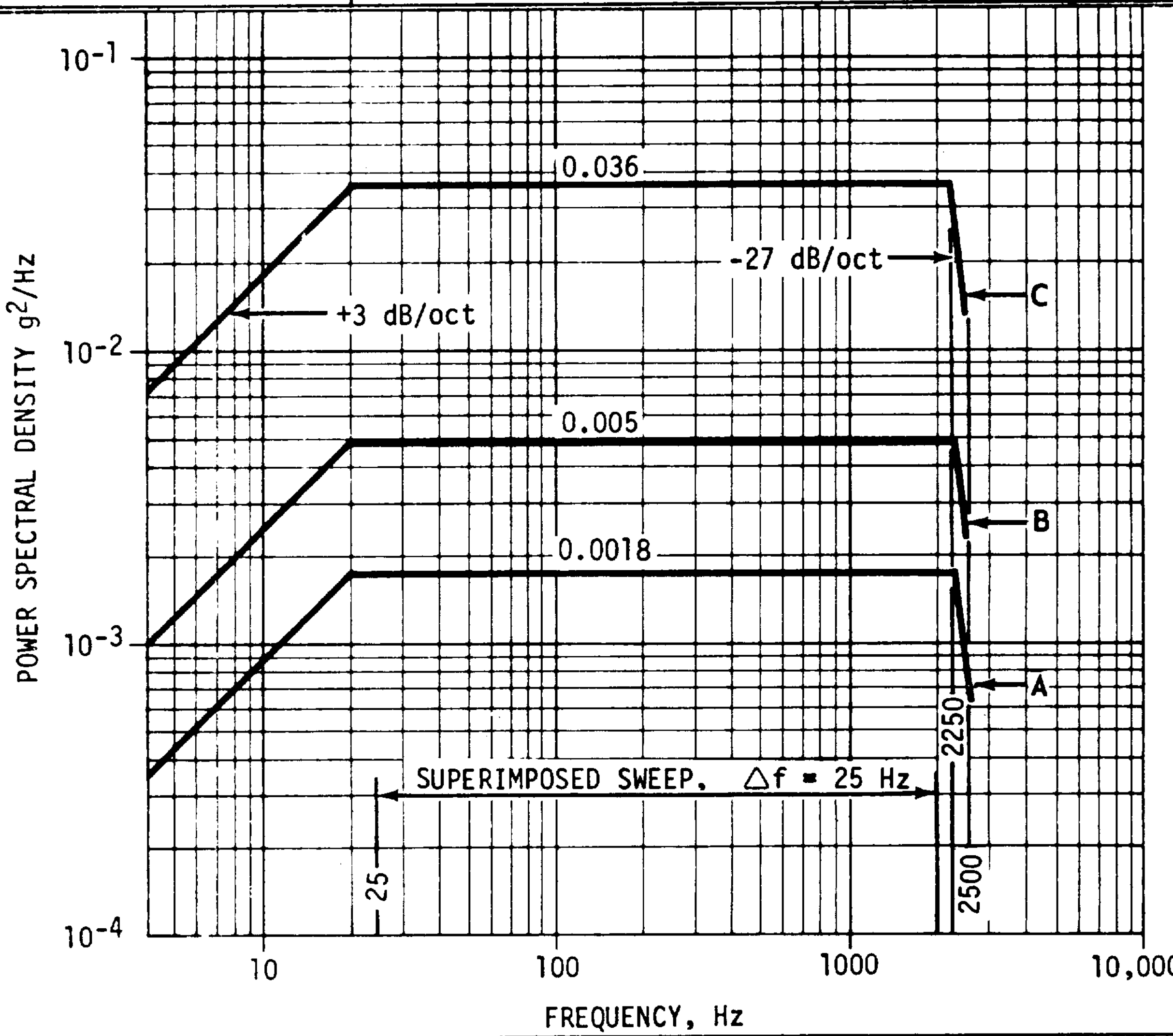
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.1.2
FLOOR BEAMS SUPPORTING GRATING, COMPARTMENTS
31A AND 41A
X-DIRECTION



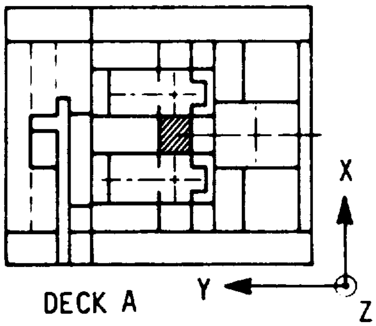
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	7.3
B	Lift-off Steady State Until Umbilical Disconnect	0.07	12.1
C	Lift-off Peak	0.3	24.6



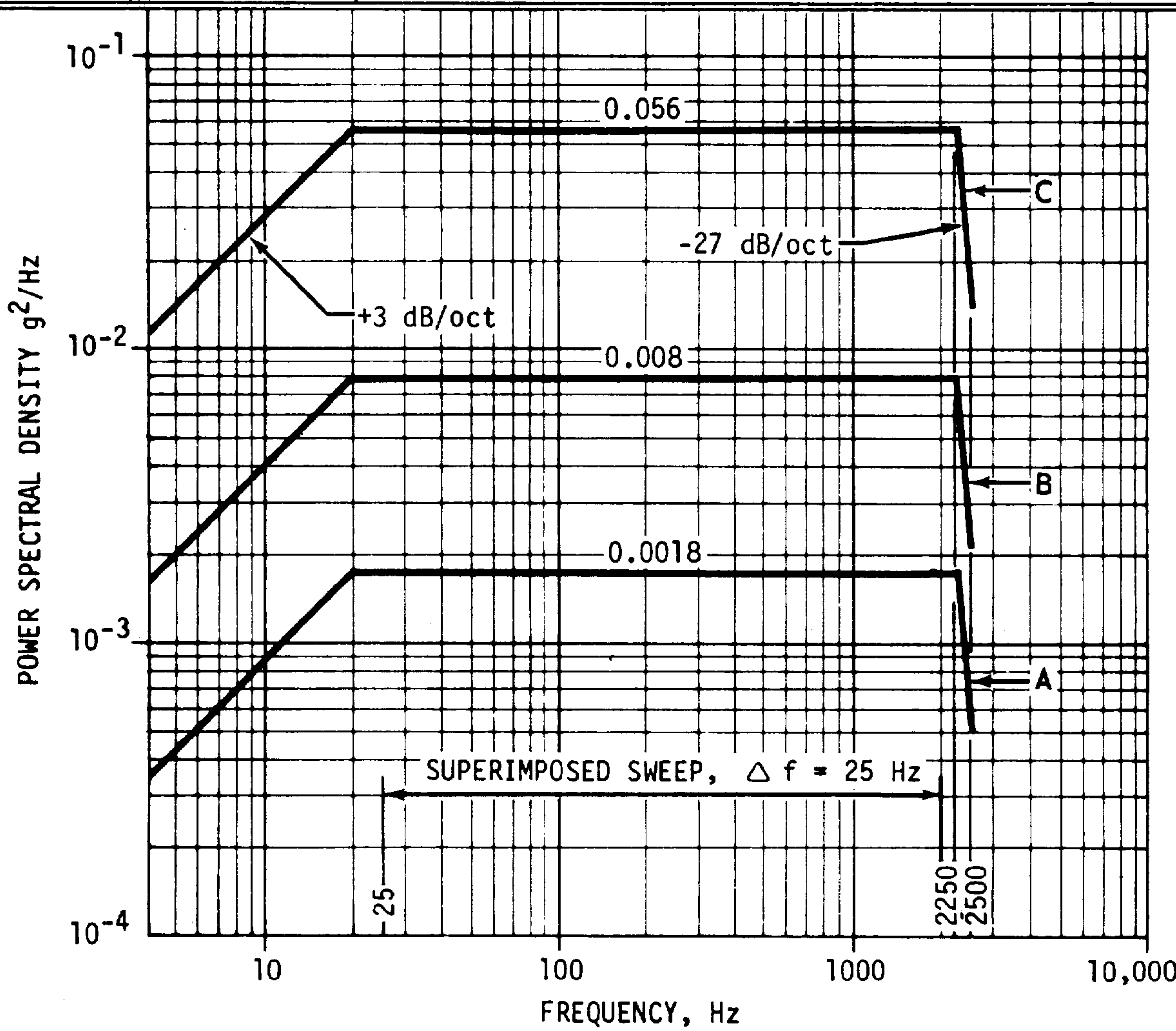
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.1.2
FLOOR BEAMS SUPPORTING GRATING, COMPARTMENTS
31A AND 41A
Y-DIRECTION



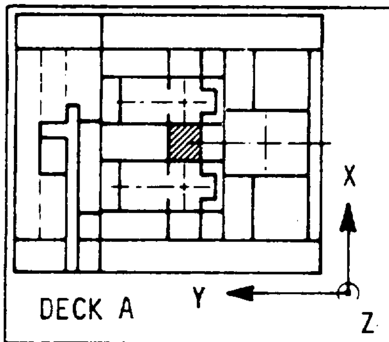
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	2.4
B	Lift-off Steady State Until Umbilical Disconnect	0.07	3.7
C	Lift-off Peak	0.18	9.5



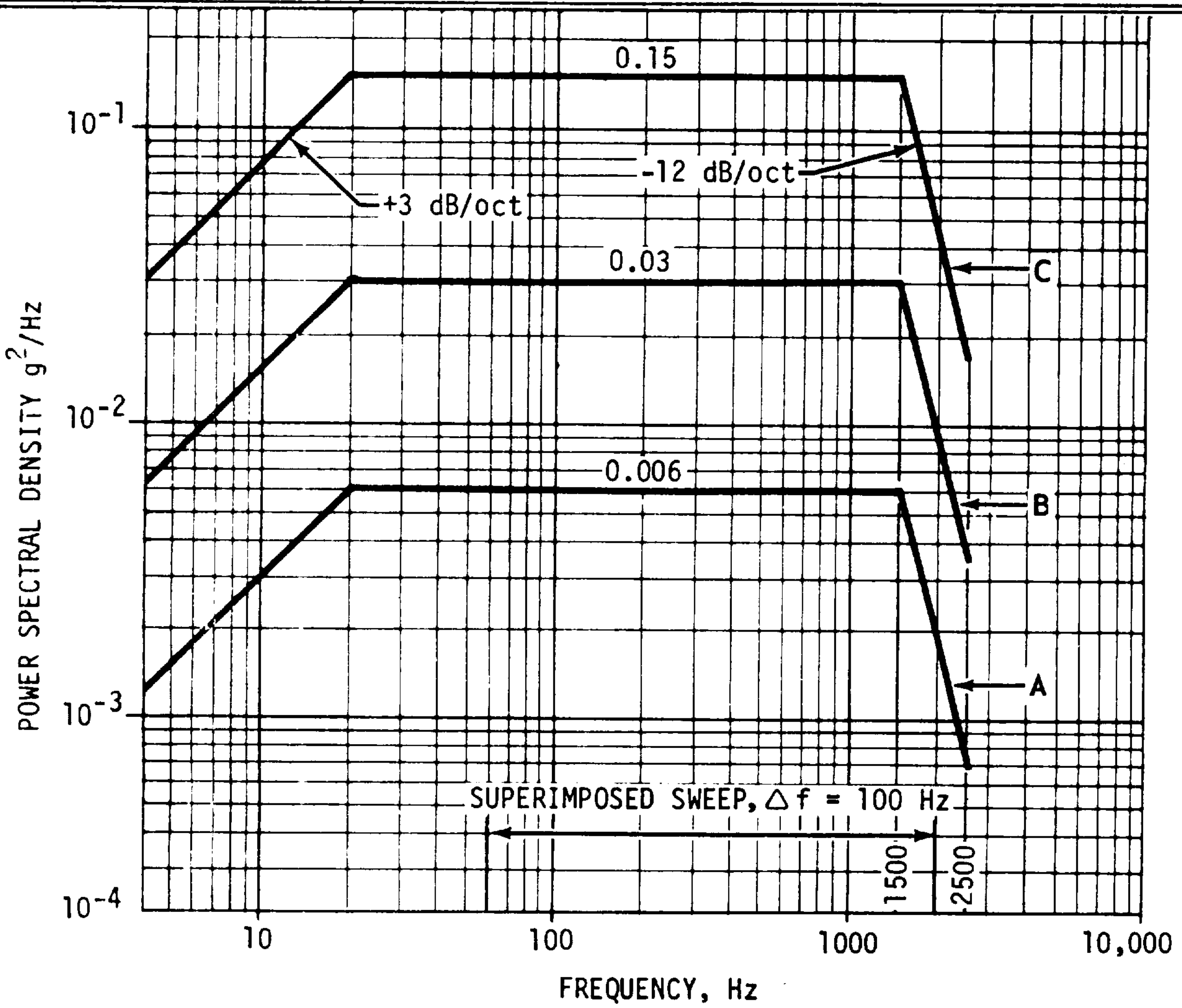
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.1.3
FLOOR BEAMS SUPPORTING GRATING.
COMPARTMENT 37A
Y-DIRECTION



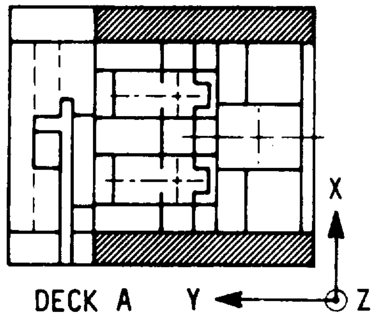
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	2.4
B	Lift-off Steady State Until Umbilical Disconnect	0.10	4.7
C	Lift-off Peak	0.25	11.9



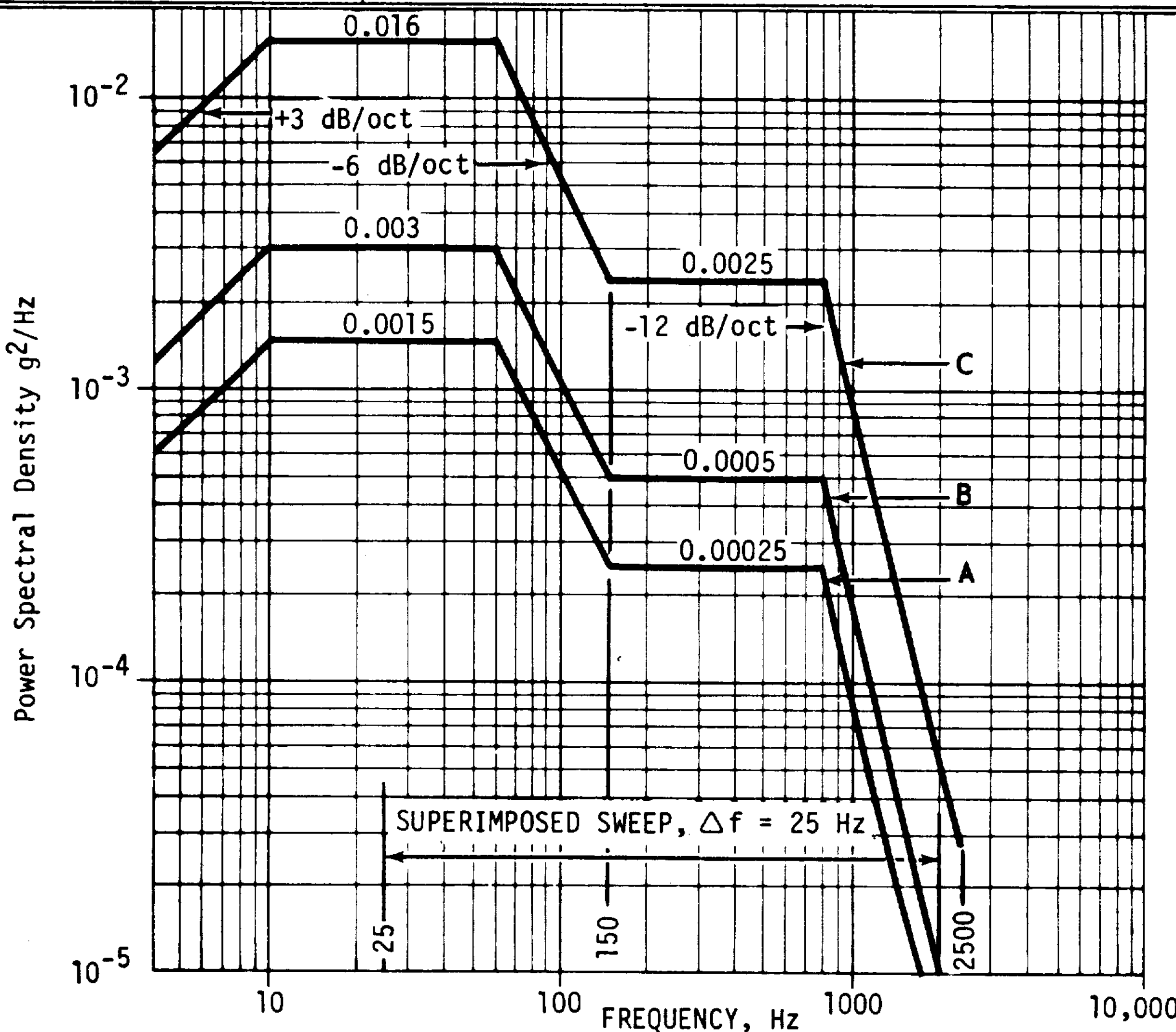
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.1.3
FLOOR BEAMS SUPPORTING GRATING,
COMPARTMENT 37A
Z-DIRECTION



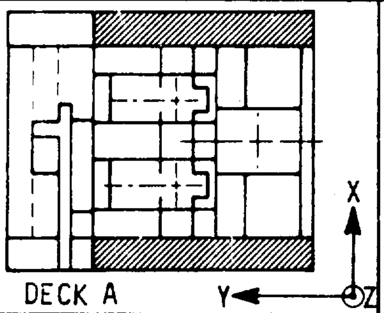
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	3.64
B	Lift-off Steady State Until Umbilical Disconnect	0.1	8.2
C	Lift-off Peak	0.7	18.8



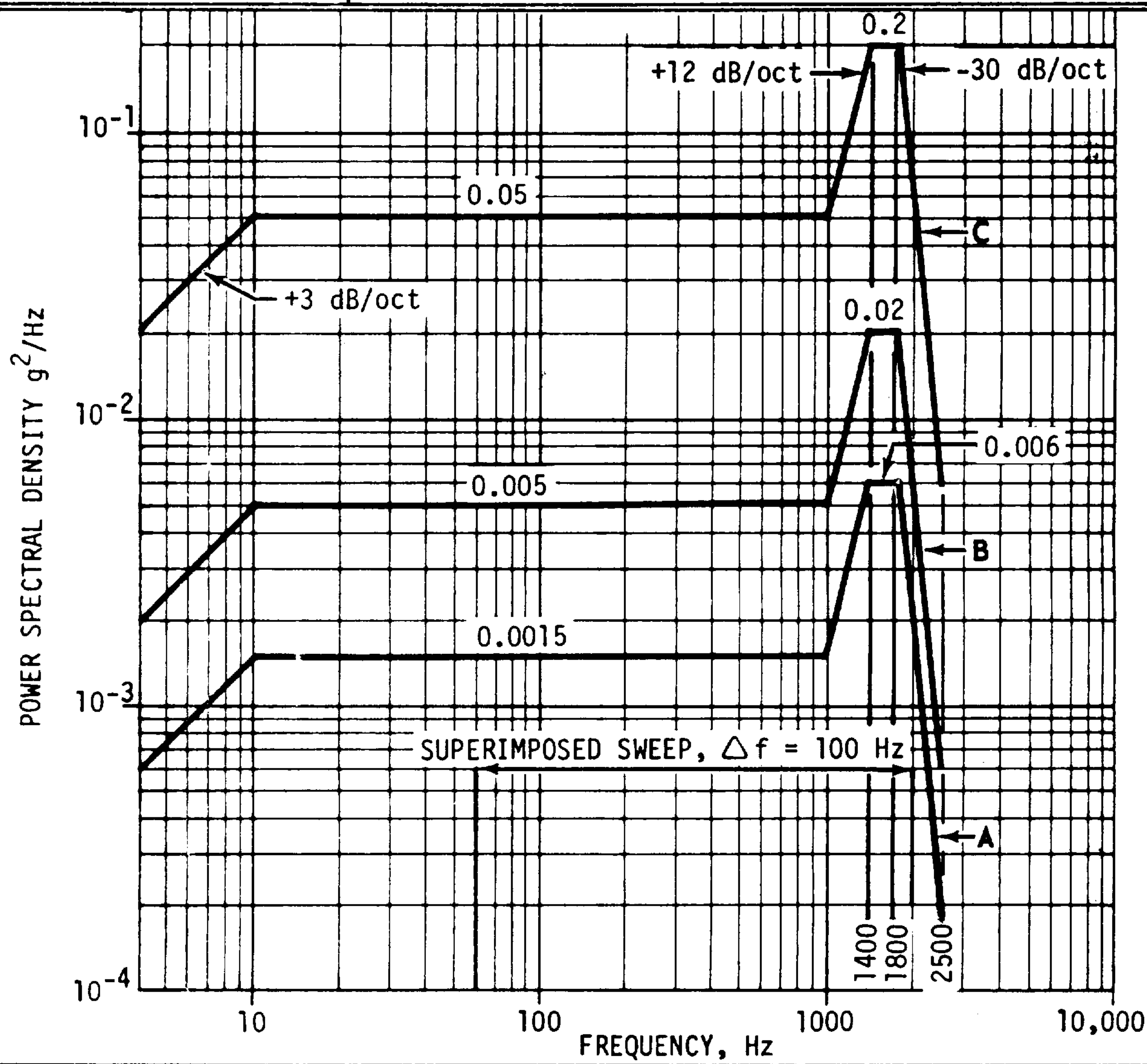
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.2
MAIN FLOOR STRUCTURE, COMPARTMENTS 2A AND 16A
X AND Y DIRECTIONS



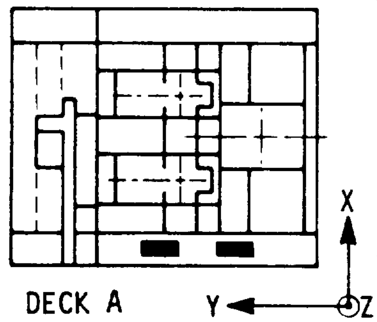
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	0.80
B	Lift-off Steady State Until Umbilical Disconnect	0.01	1.0
C	Lift-off Peak	0.02	2.05



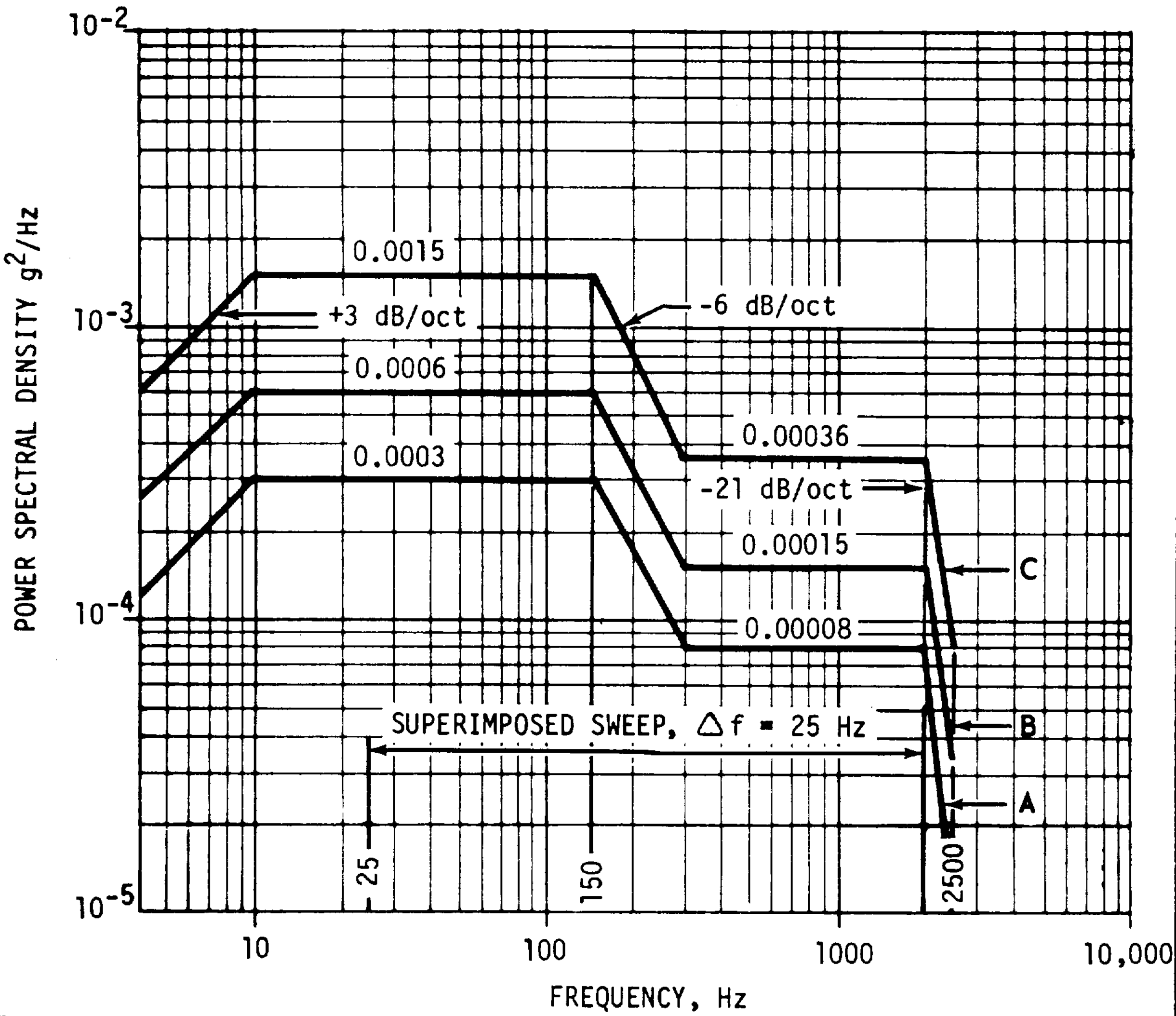
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.2
MAIN FLOOR STRUCTURE, COMPARTMENTS 2A AND 16A
Z-DIRECTION



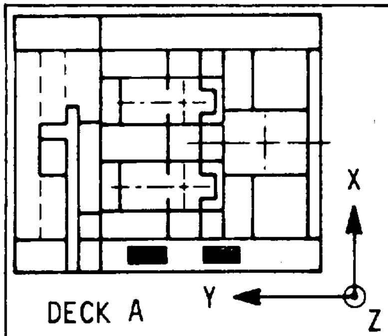
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	2.7
B	Lift-off Steady State Until Umbilical Disconnect	0.02	4.8
C	Lift-off Peak	0.5	16.2



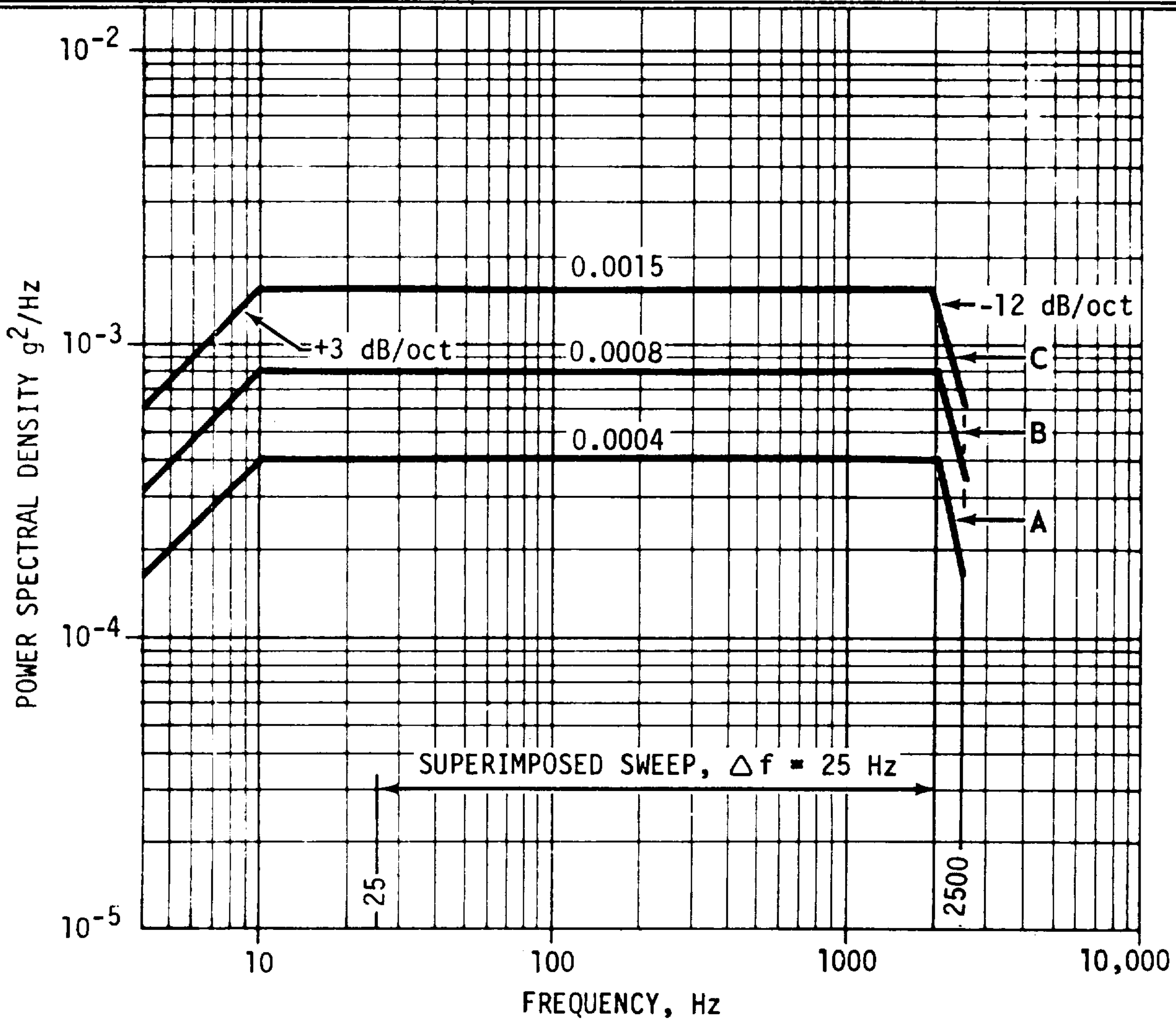
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.2.1
BASE OF INSTRUMENTATION POWER UNIT SUBSTATION AND
BASE OF INDUSTRIAL POWER UNIT SUBSTATION.
COMPARTMENT 16A
X AND Y DIRECTIONS



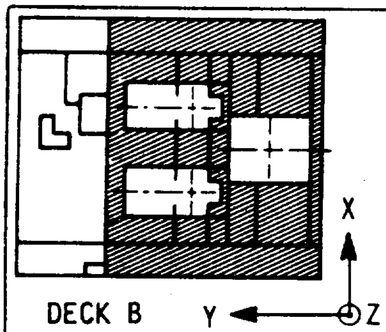
Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	0.70
B	Lift-off Steady State Until Umbilical Disconnect	0.01	0.82
C	Lift-off Peak	0.01	1.13



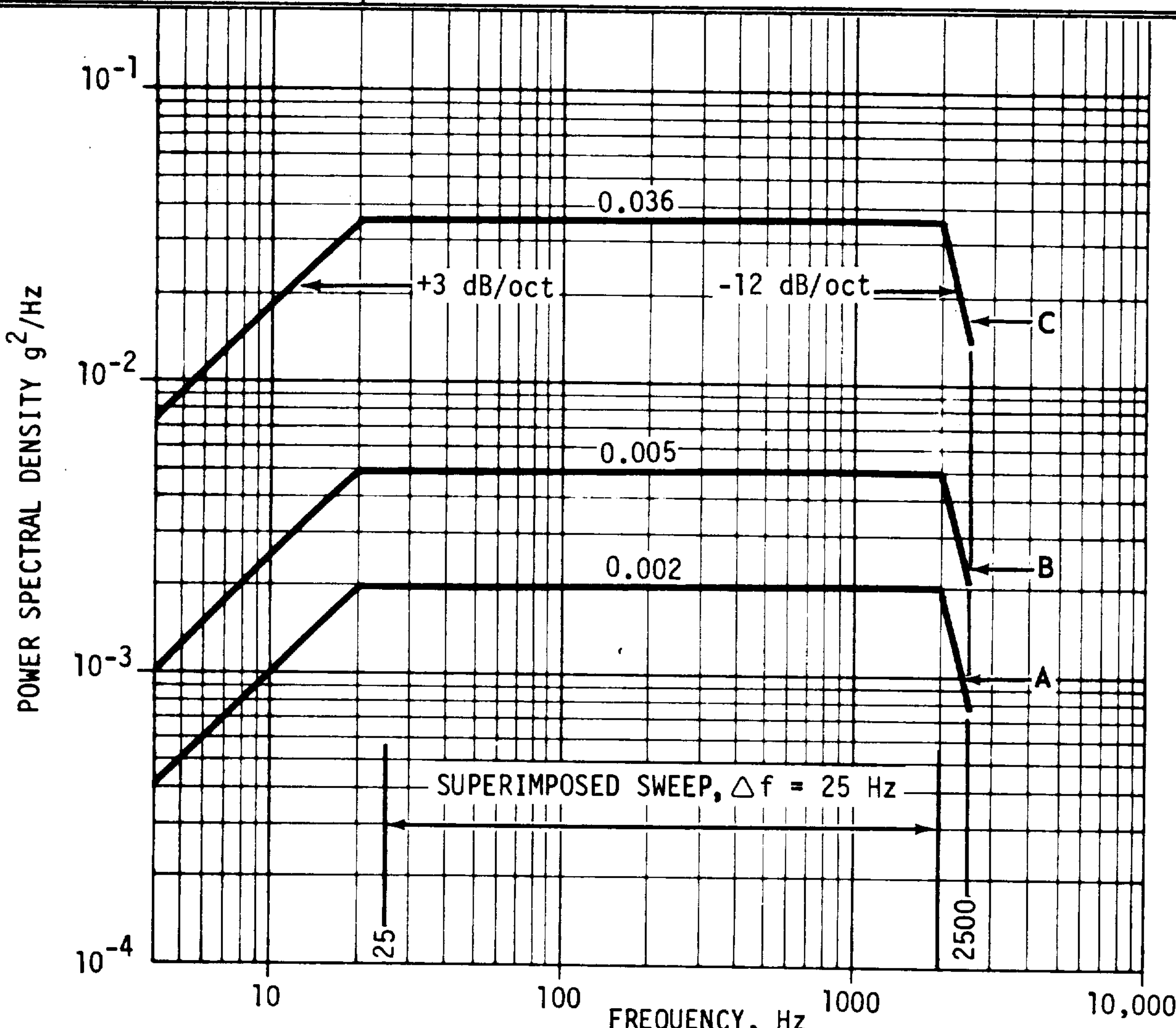
RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.2.1
BASE OF INSTRUMENTATION POWER UNIT SUBSTATION AND BASE OF INDUSTRIAL POWER UNIT SUBSTATION.
COMPARTMENT 16A
Z-DIRECTION



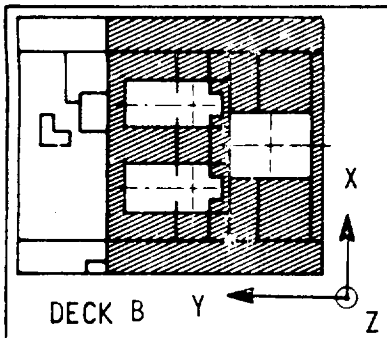
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.1
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.5
C	Lift-off Peak	0.03	2.1



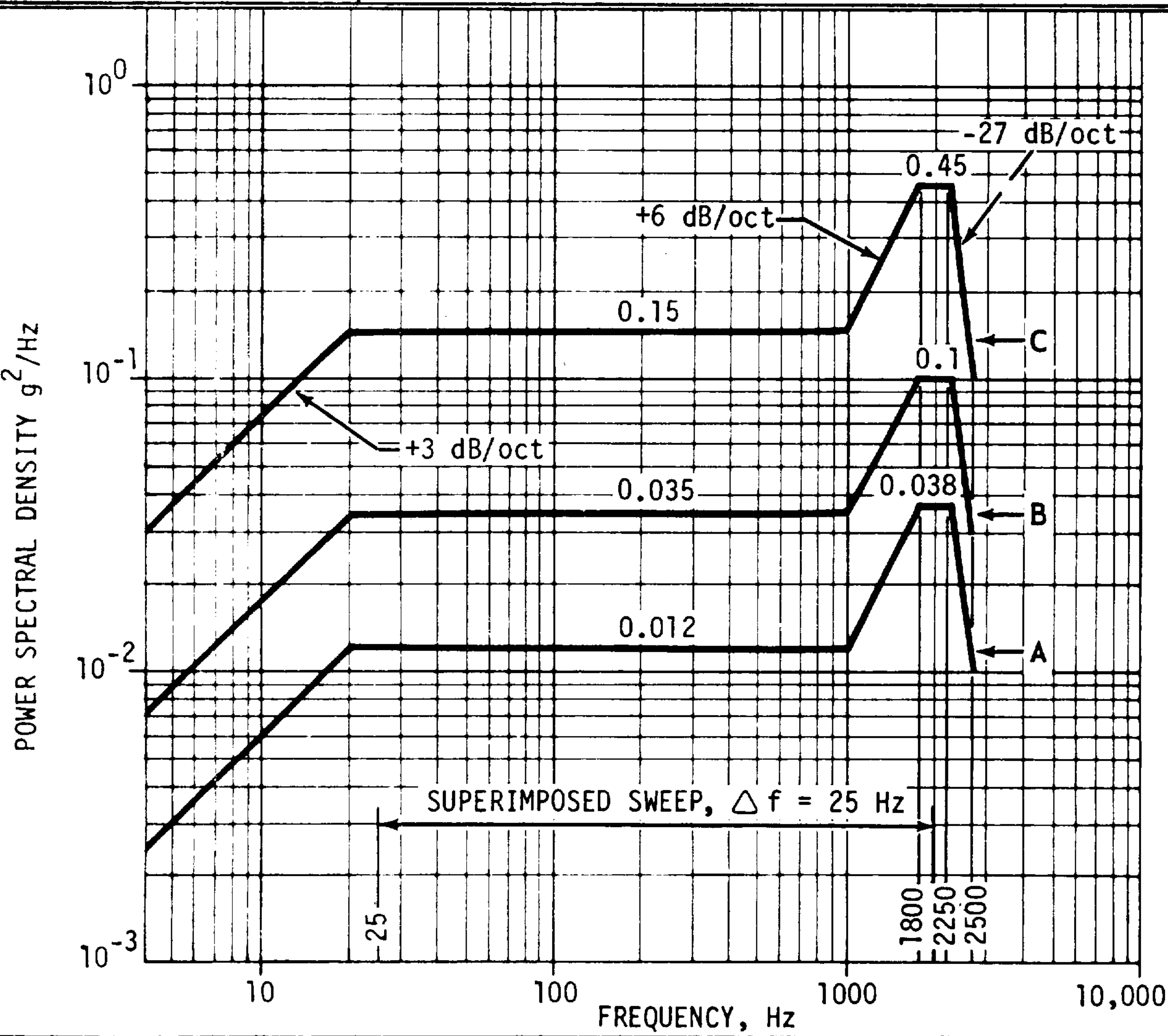
RANDOM VIBRATION ENVIRONMENT
ZONE 1.3.1.1, 1.3.1.2, 1.3.1.3, 1.3.1.4, 1.3.1.5 AND 1.3.2. FLOOR BEAMS AND DECKING, B-LEVEL COMPARTMENTS IN ZONE 1.3
X-DIRECTION



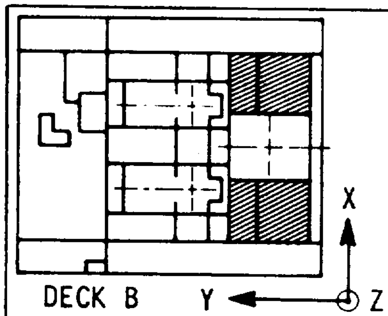
Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	2.4
B	Lift-off Steady State Until Umbilical Disconnect	0.1	3.8
C	Lift-off Peak	0.2	9.4



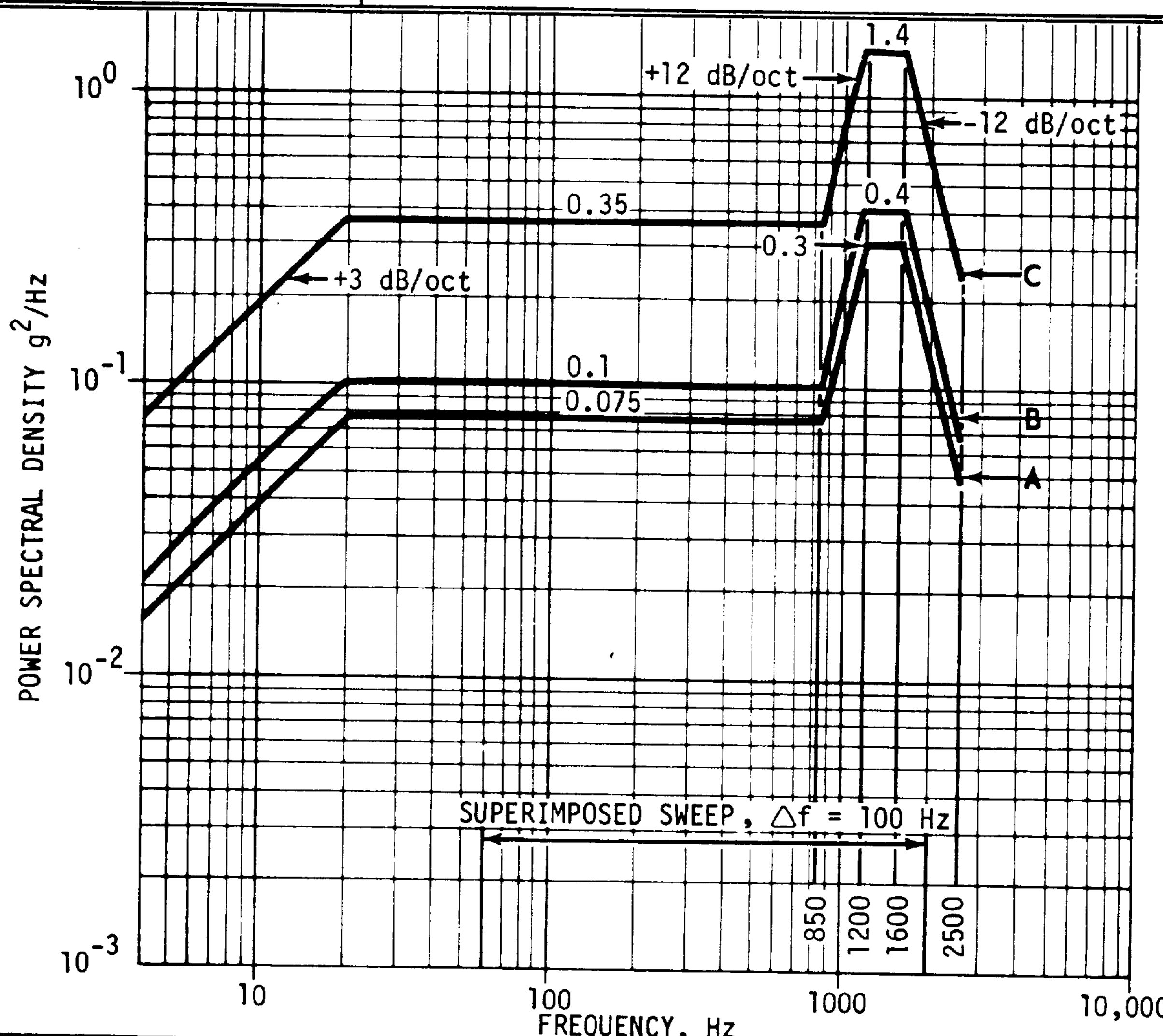
RANDOM VIBRATION ENVIRONMENT
ZONE 1.3.1.1, 1.3.1.2, 1.3.1.3, 1.3.1.4, 1.3.1.5 AND 1.3.2. FLOOR BEAMS AND DECKING. B-LEVEL COMPARTMENTS IN ZONE 1.3
Y-DIRECTION



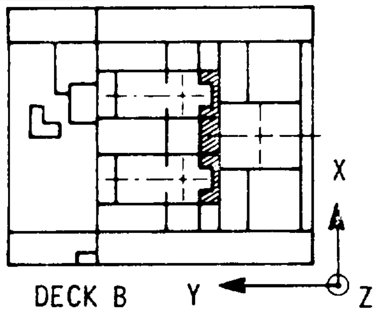
Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	7.4
B	Lift-off Steady State Until Umbilical Disconnect	0.2	12.4
C	Lift-off Peak	0.4	25.8



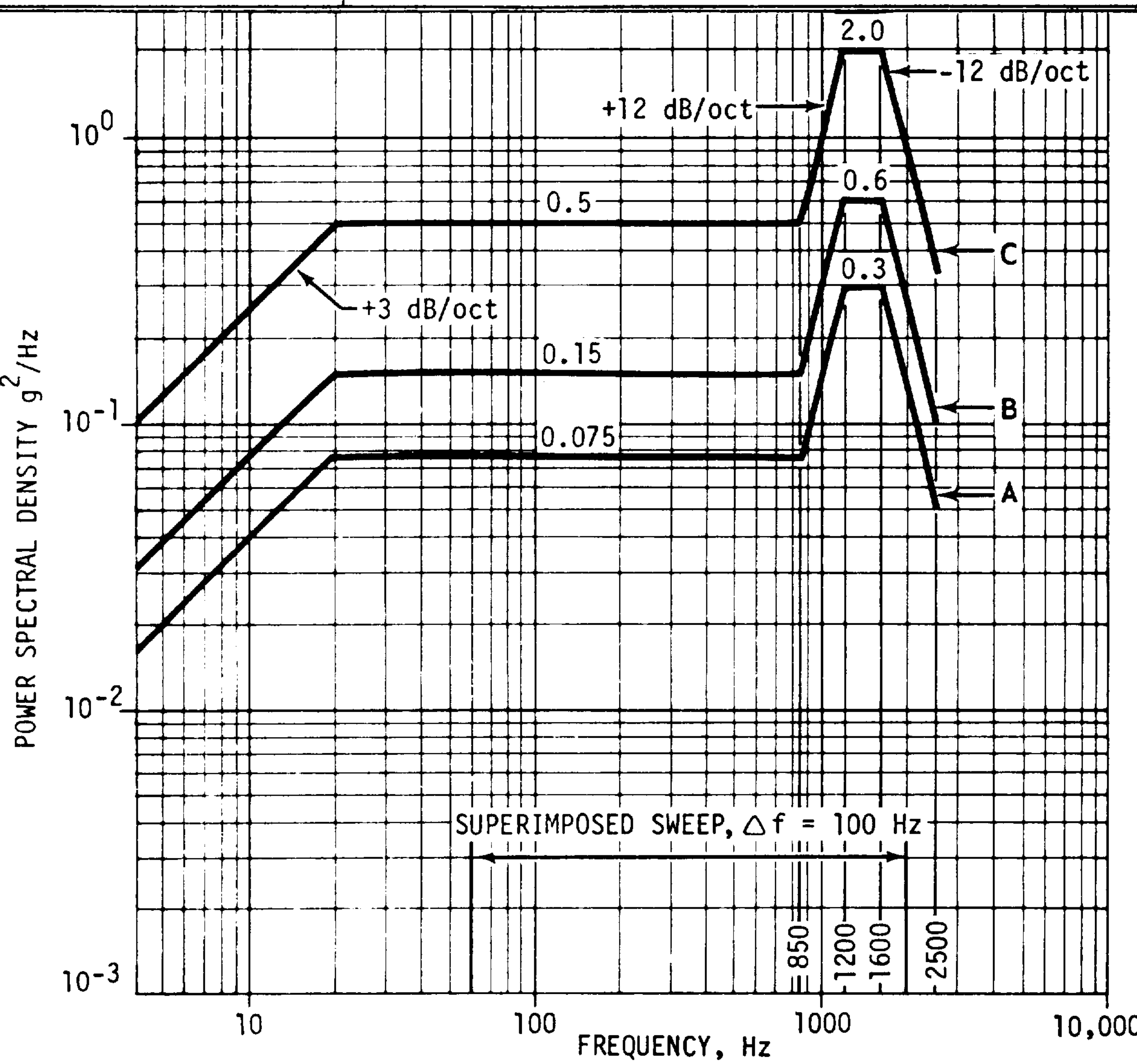
RANDOM VIBRATION ENVIRONMENT
ZONE 1.3.1.1
FLOOR BEAMS AND DECKING. COMPARTMENTS 33B, 34B, 43B, AND 44B
Z-DIRECTION



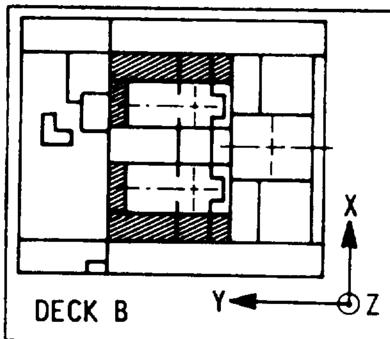
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.3	19.8
B	Lift-off Steady State Until Umbilical Disconnect	0.4	22.8
C	Lift-off Peak	1.5	42.8



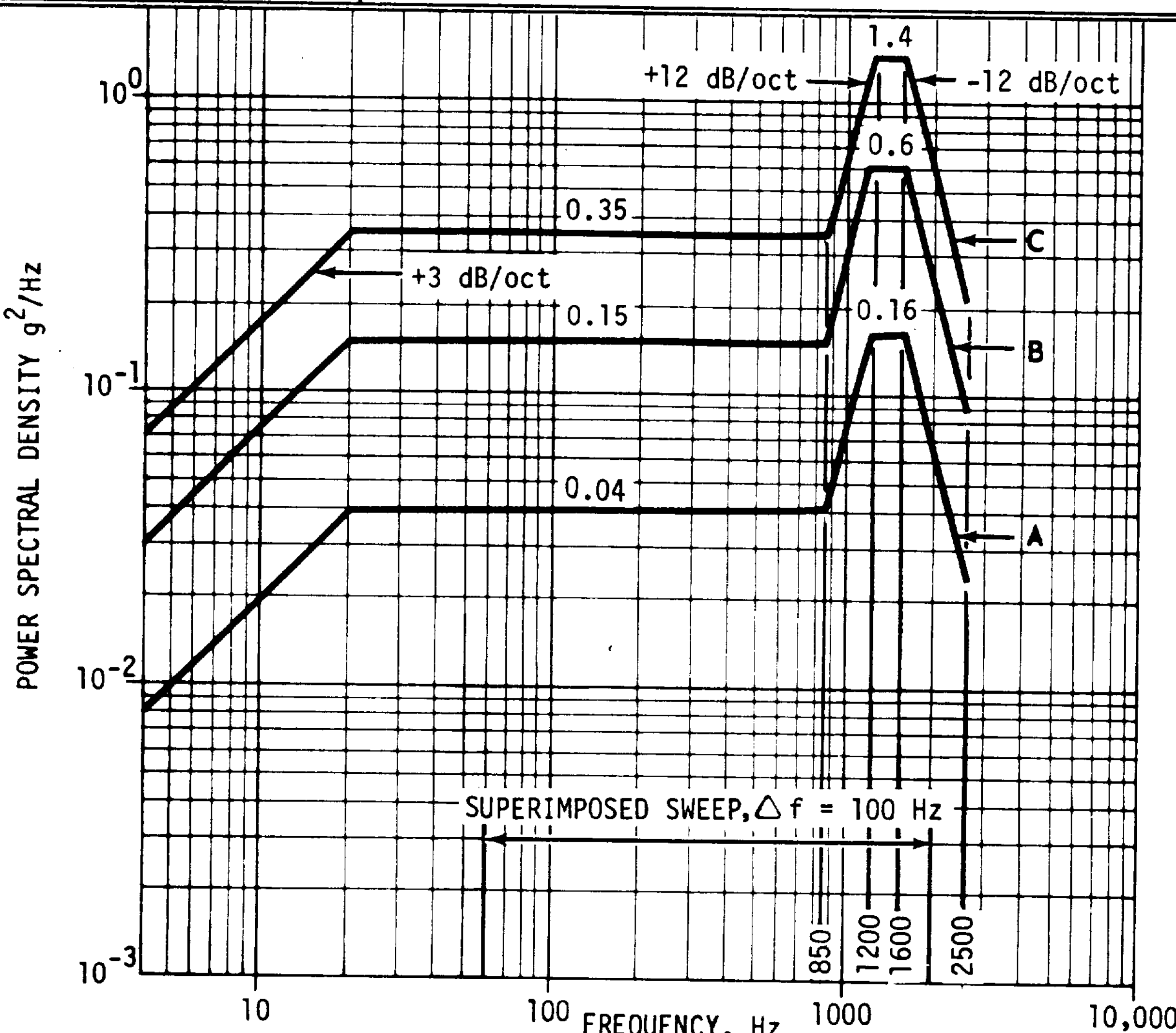
RANDOM VIBRATION ENVIRONMENT
ZONE 1.3.1.2
FLOOR BEAMS AND DECKING. COMPARTMENTS 35AB, 38AB AND 39AB
Z-DIRECTION



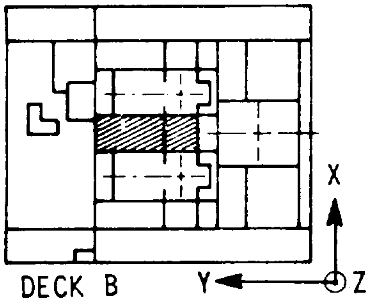
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.3	19.8
B	Lift-off Steady State Until Umbilical Disconnect	0.5	27.8
C	Lift-off Peak	2.0	51.0



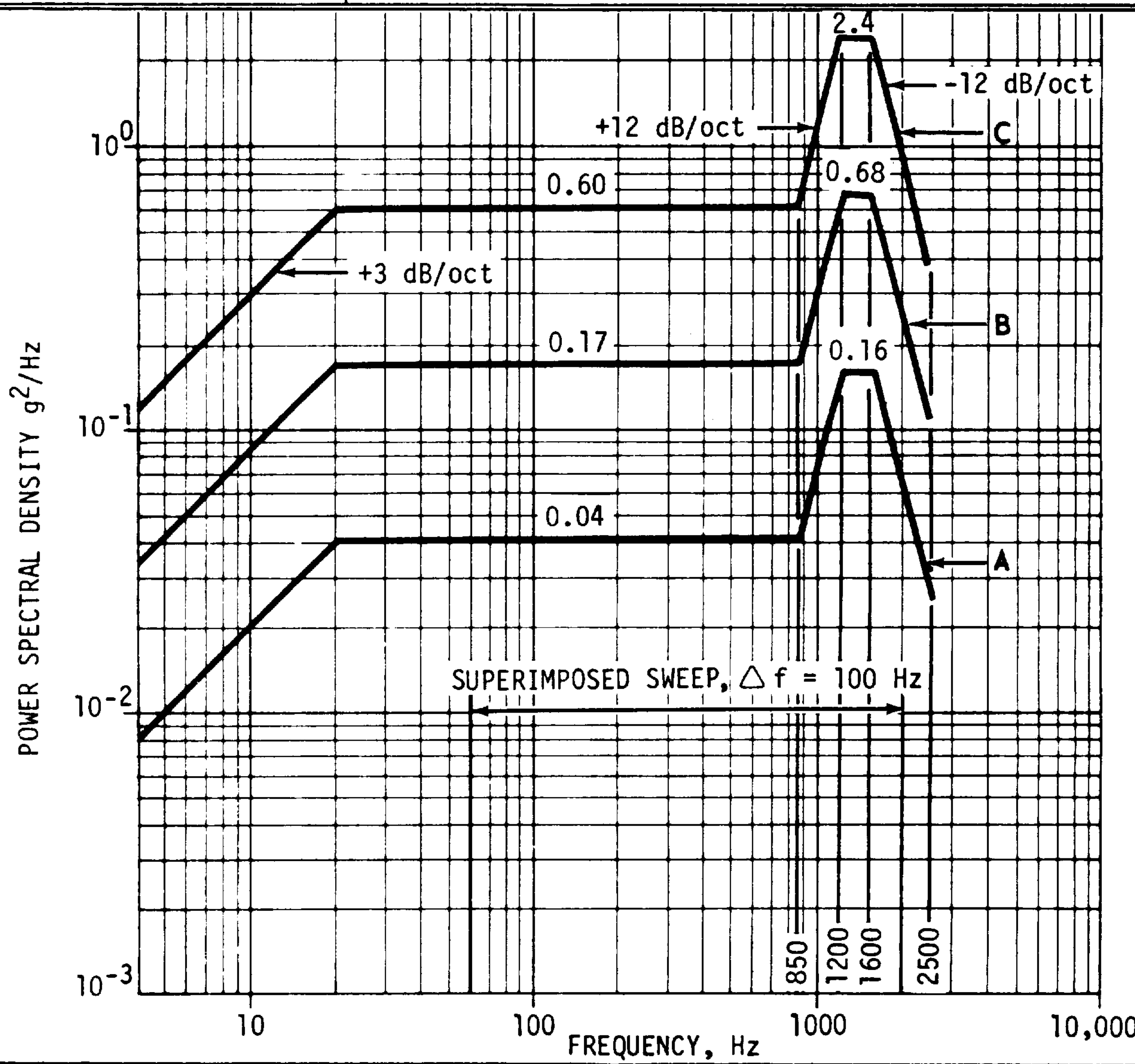
RANDOM VIBRATION ENVIRONMENT
ZONE 1.3.1.3
FLOOR BEAMS AND DECKING. COMPARTMENTS 30AB, 31B, 32AB, 40AB, 41B, 42AB, 46AB AND 47AB
Z-DIRECTION



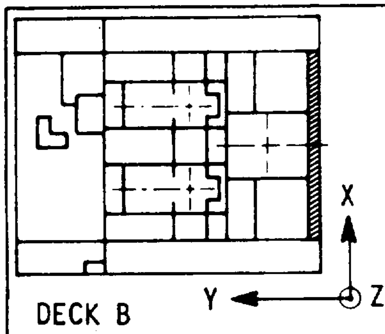
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.2	14.6
B	Lift-off Steady State Until Umbilical Disconnect	0.5	27.8
C	Lift-off Peak	1.5	42.8



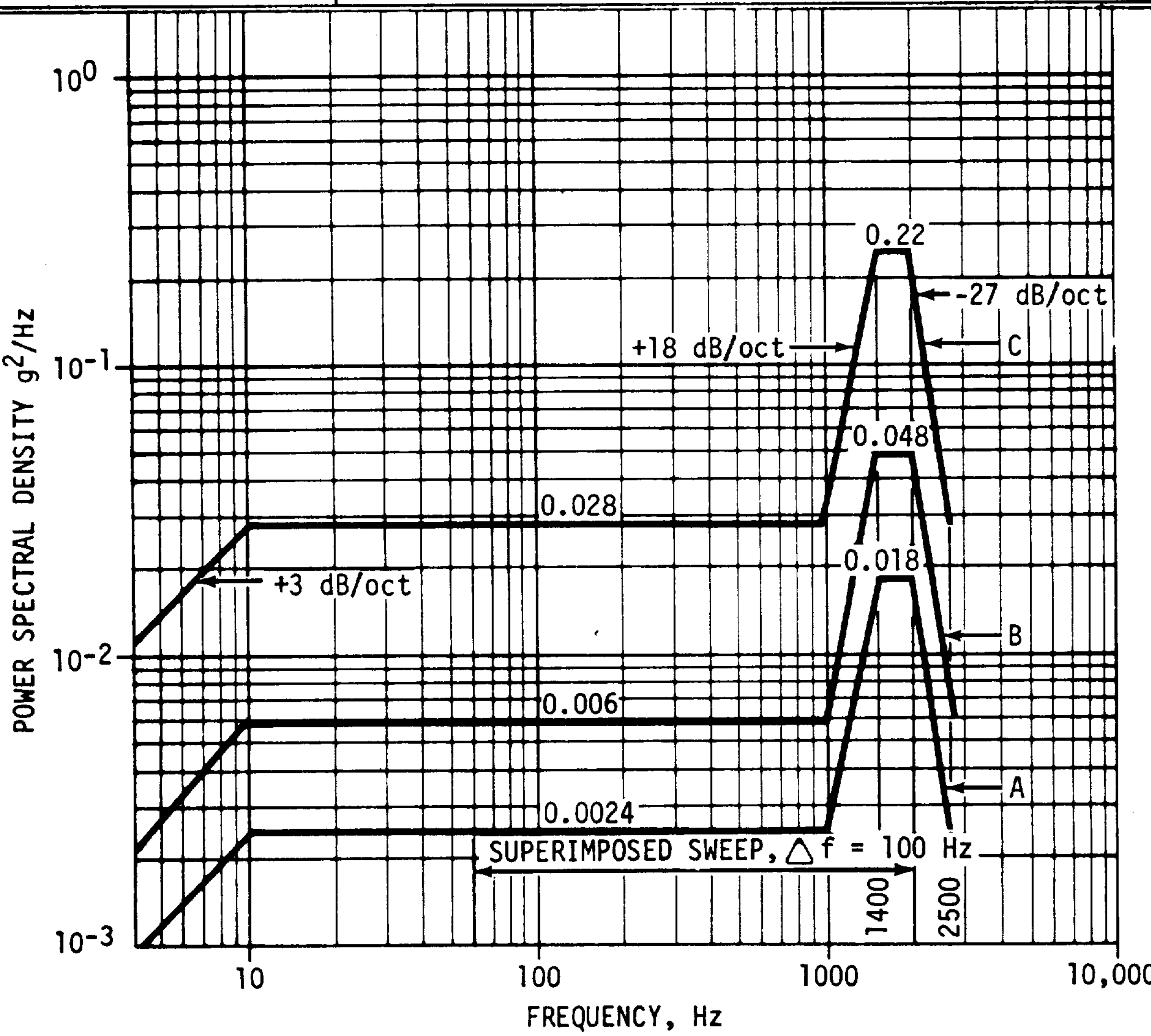
RANDOM VIBRATION ENVIRONMENT
ZONE 1.3.1.4
FLOOR BEAMS AND DECKING. COMPARTMENTS 36AB AND 37AB
Z-DIRECTION



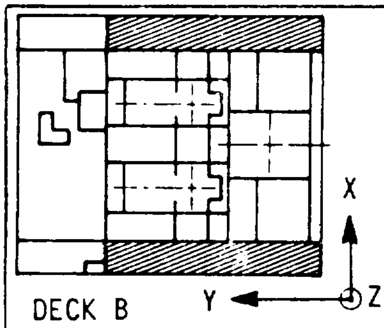
Sym.	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.2	14.6
B	Lift-off Steady State Until Umbilical Disconnect	0.6	29.6
C	Lift-off Peak	2.2	55.7



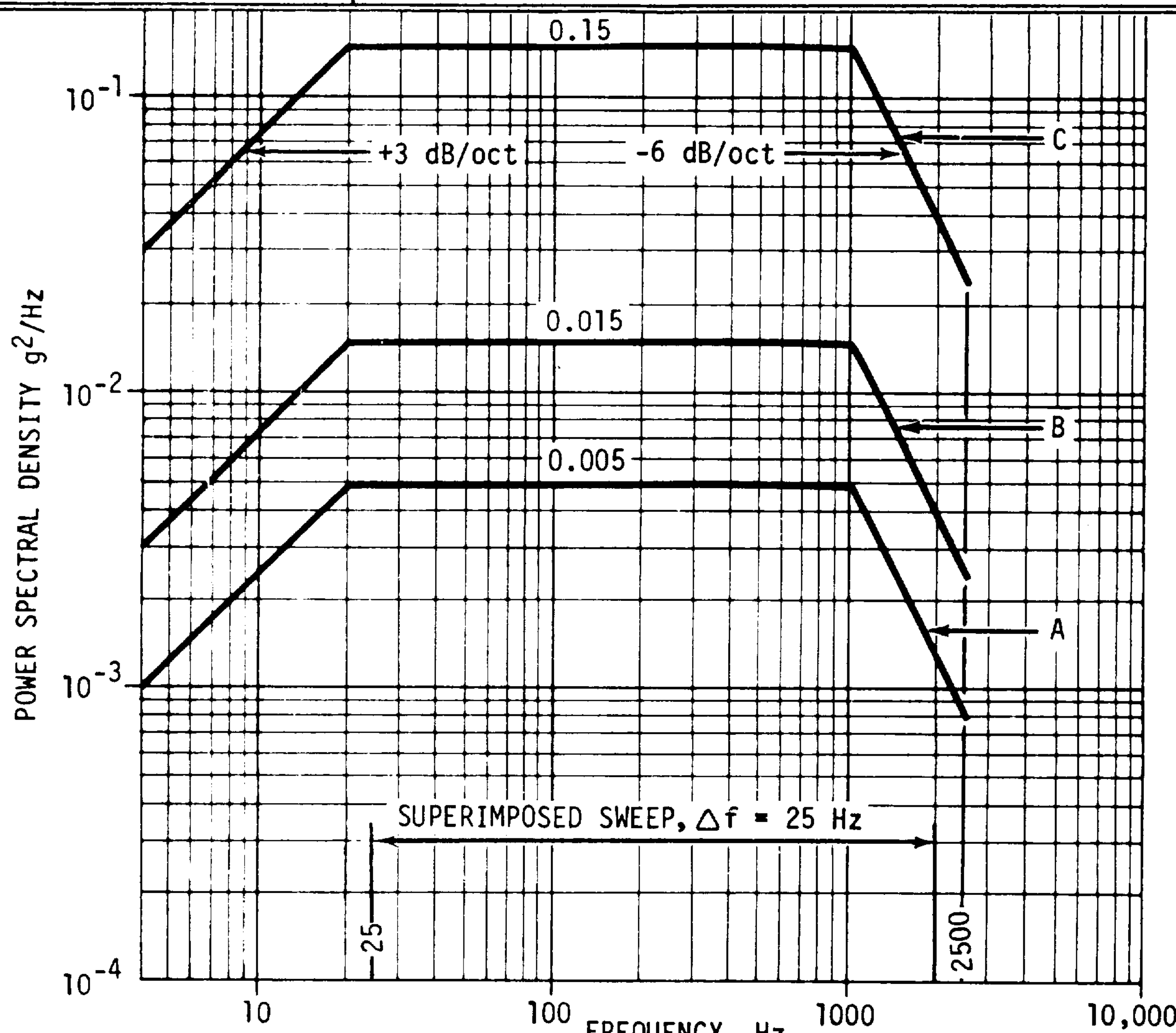
RANDOM VIBRATION ENVIRONMENT
ZONE 1.3.1.5
FLOOR STRUCTURE, COMPARTMENT 45AB
Z-DIRECTION



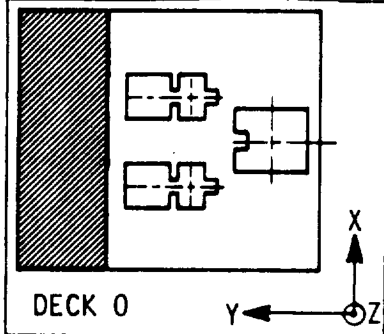
Sym.	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	4.8
B	Lift-off Steady State Until Umbilical Disconnect	0.05	7.6
C	Lift-off Peak	0.50	17.3



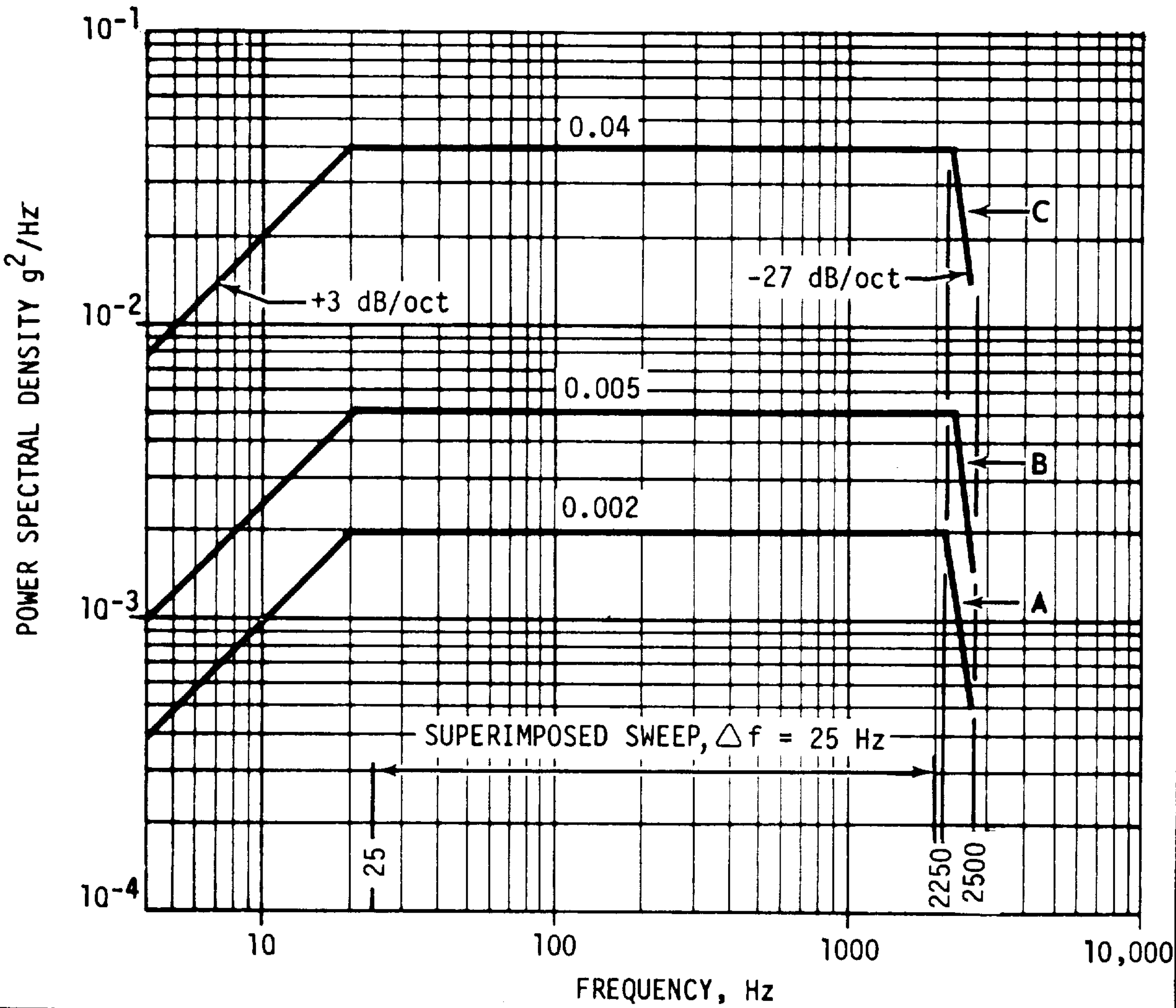
RANDOM VIBRATION ENVIRONMENT
ZONE 1.3.2
FLOOR BEAMS AND DECKING. COMPARTMENTS 2B AND 16B
Z-DIRECTION



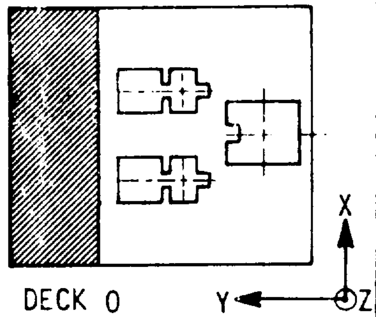
Sym.	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	3.2
B	Lift-off Steady State Until Umbilical Disconnect	0.2	5.4
C	Lift-off Peak	0.5	15.8



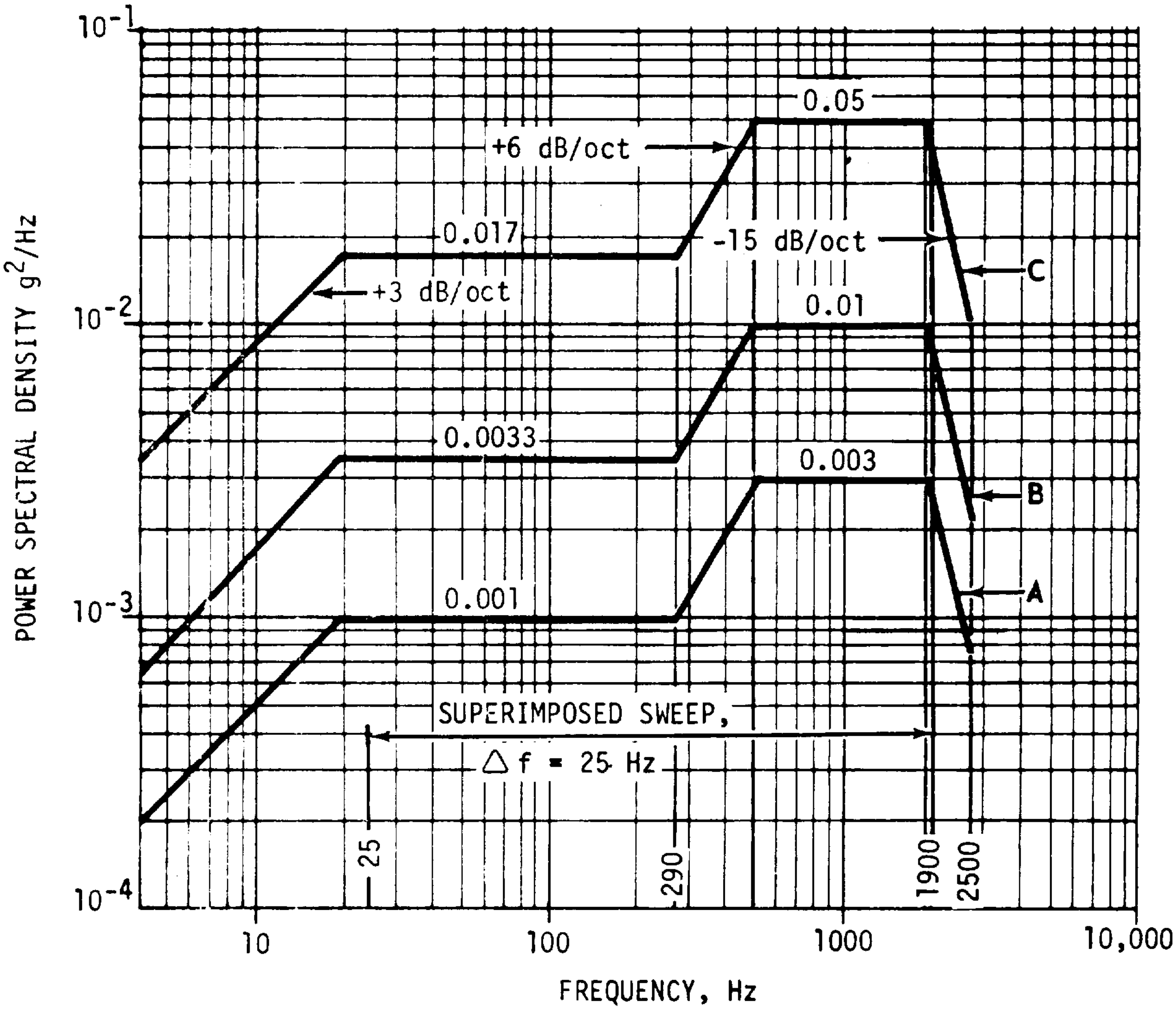
RANDOM VIBRATION ENVIRONMENT
ZONE 2.1.1
MAIN FLOOR STRUCTURE OF LAUNCHER DECK
X-DIRECTION



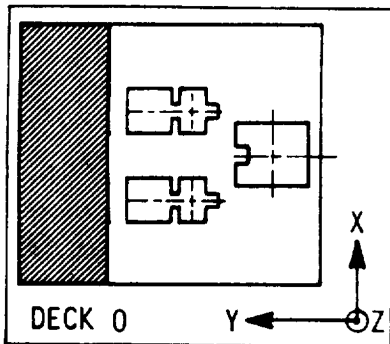
Sym.	Launch Stage	Sweep △ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	2.5
B	Lift-off Steady State Until Umbilical Disconnect	0.07	3.7
C	Lift-off Peak	0.20	10.0



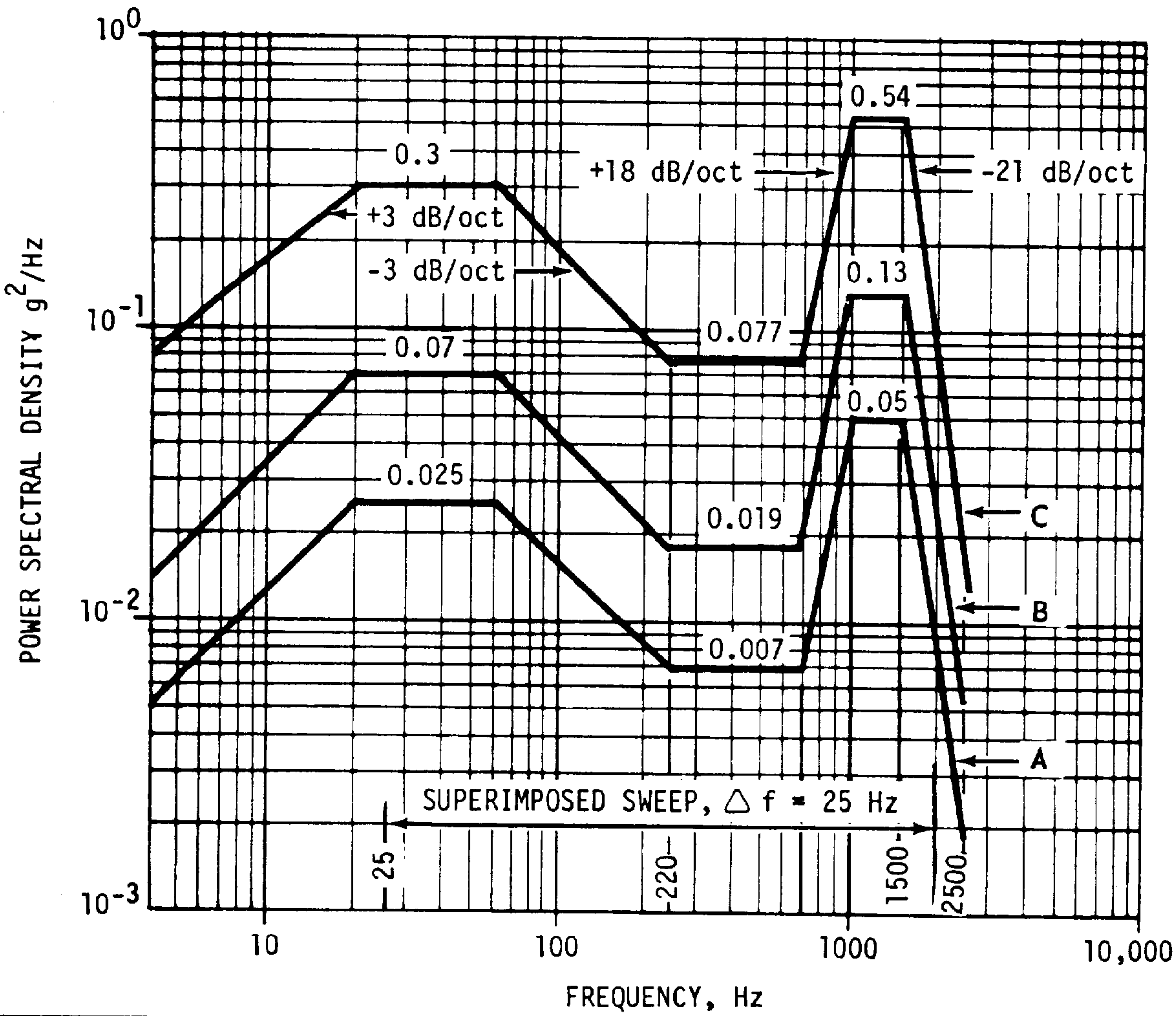
RANDOM VIBRATION ENVIRONMENT
ZONE 2.1.1
MAIN FLOOR STRUCTURE OF LAUNCHER DECK
Y-DIRECTION



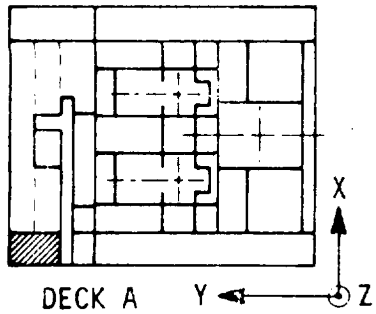
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	2.5
B	Lift-off Steady State Until Umbilical Disconnect	0.03	4.5
C	Lift-off Peak	0.25	10.2



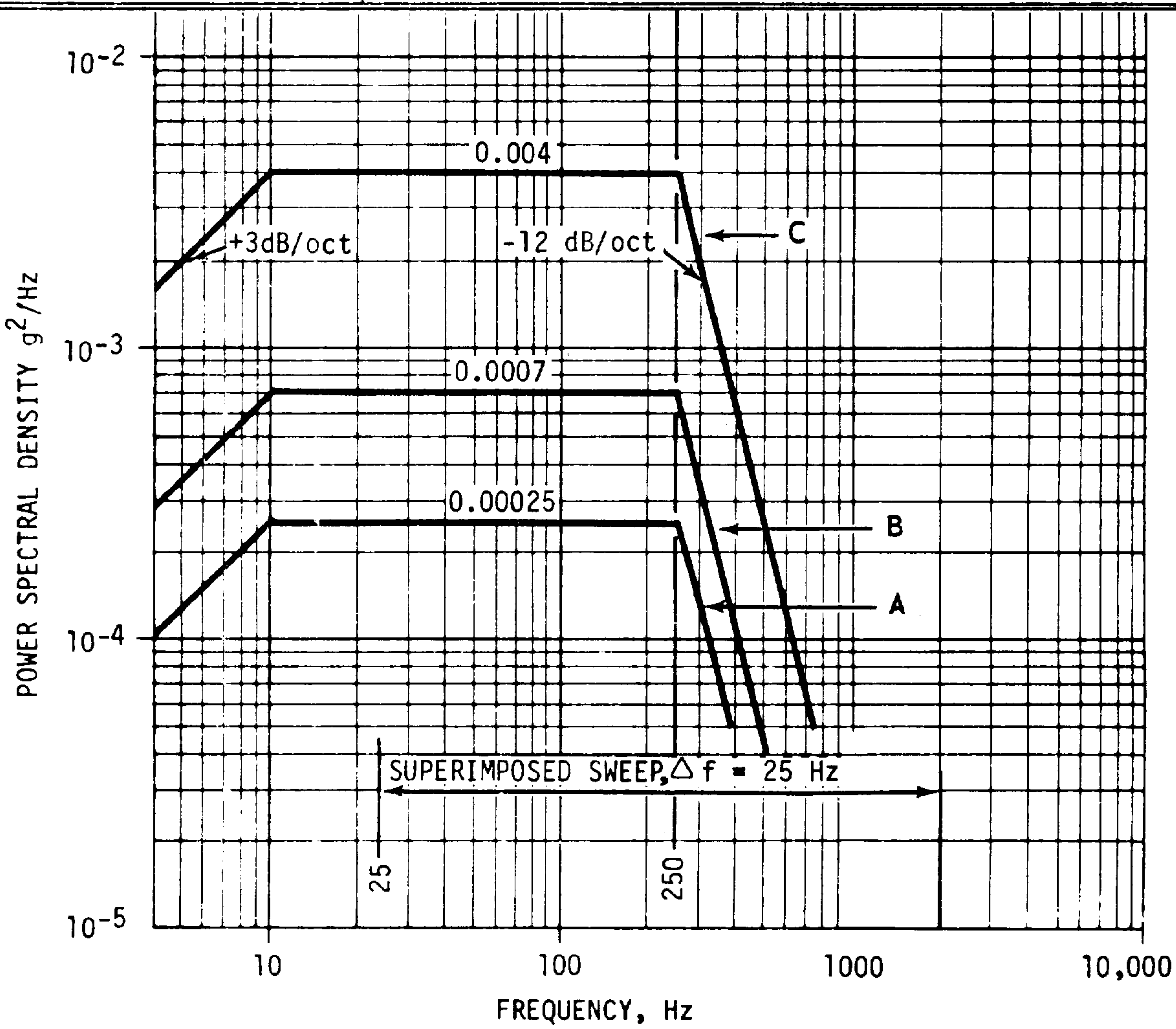
RANDOM VIBRATION ENVIRONMENT
ZONE 2.1.1
MAIN FLOOR STRUCTURE OF LAUNCHER DECK
Z-DIRECTION



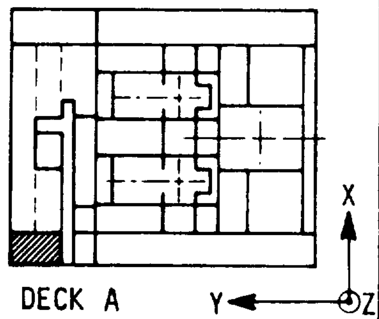
Sym.	Launch Stage	Sweep △ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.025	7.1
B	Lift-off Steady State Until Umbilical Disconnect	0.07	11.5
C	Lift-off Peak	0.32	23.5



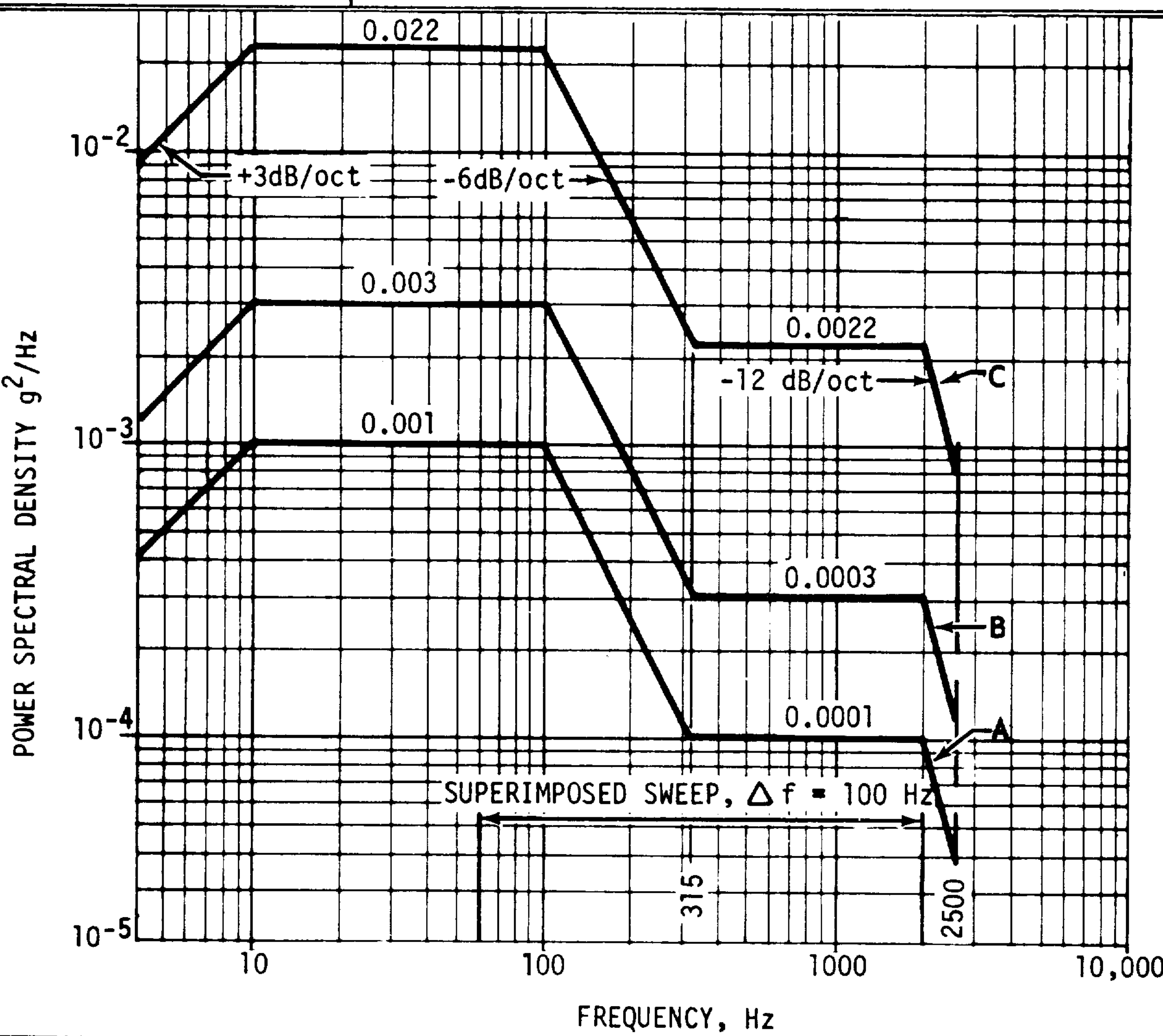
RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.1.1
SHOCK MOUNTED FLOOR, COMPARTMENT 15A
X AND Y DIRECTIONS



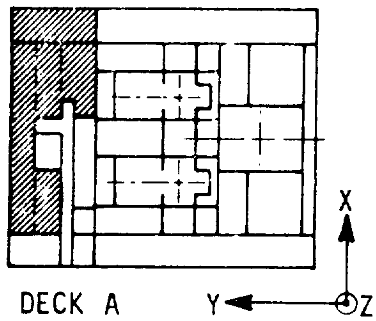
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.003	0.40
B	Lift-off Steady State Until Umbilical Disconnect	0.003	0.55
C	Lift-off Peak	0.01	1.25



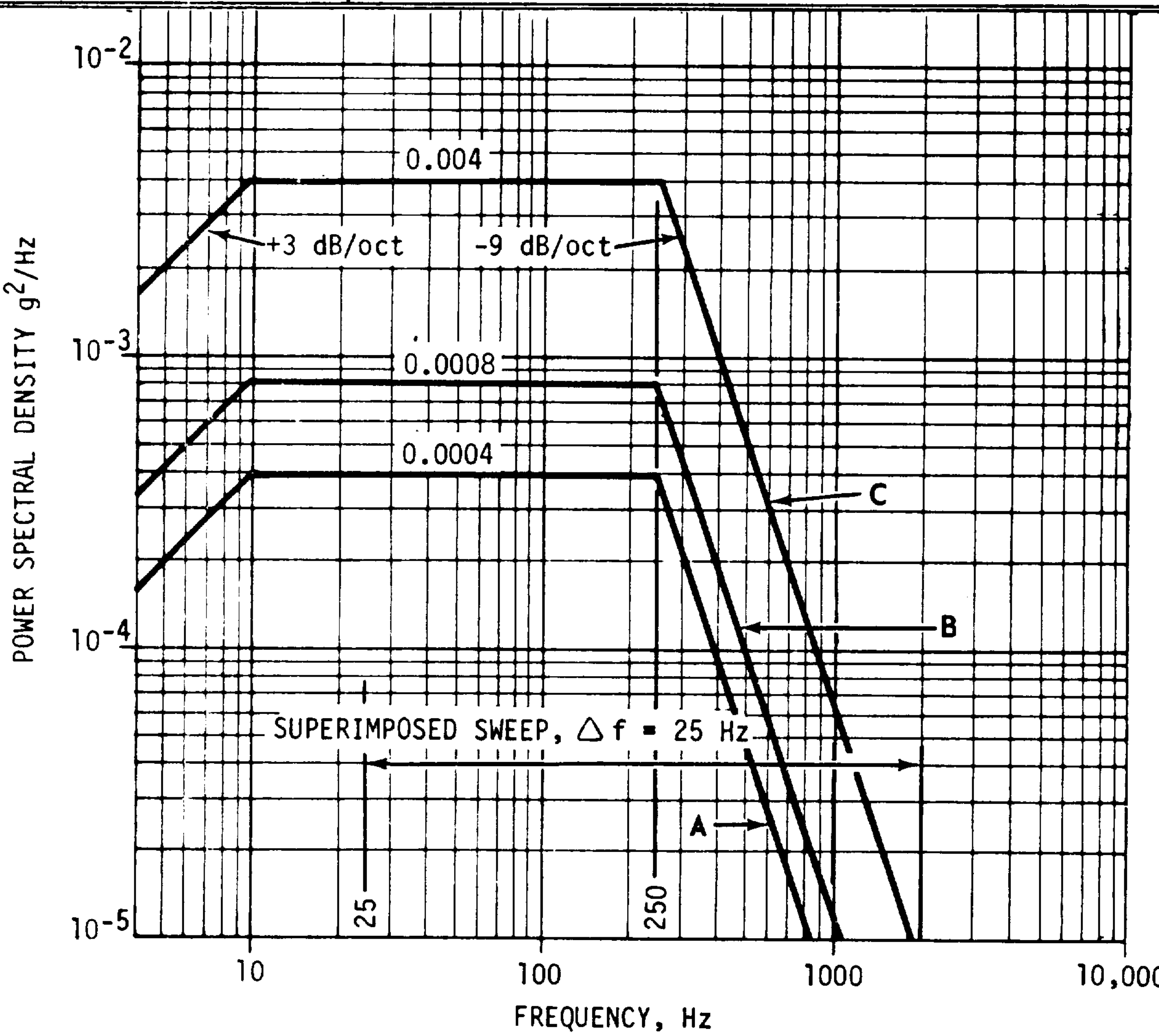
RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.1.1
SHOCK MOUNTED FLOORS. COMPARTMENT 15A
Z-DIRECTION



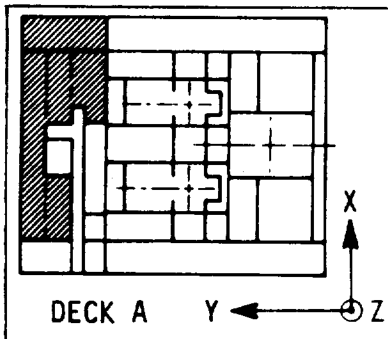
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.003	0.8
B	Lift-off Steady State Until Umbilical Disconnect	0.005	1.3
C	Lift-off Peak	0.02	3.2



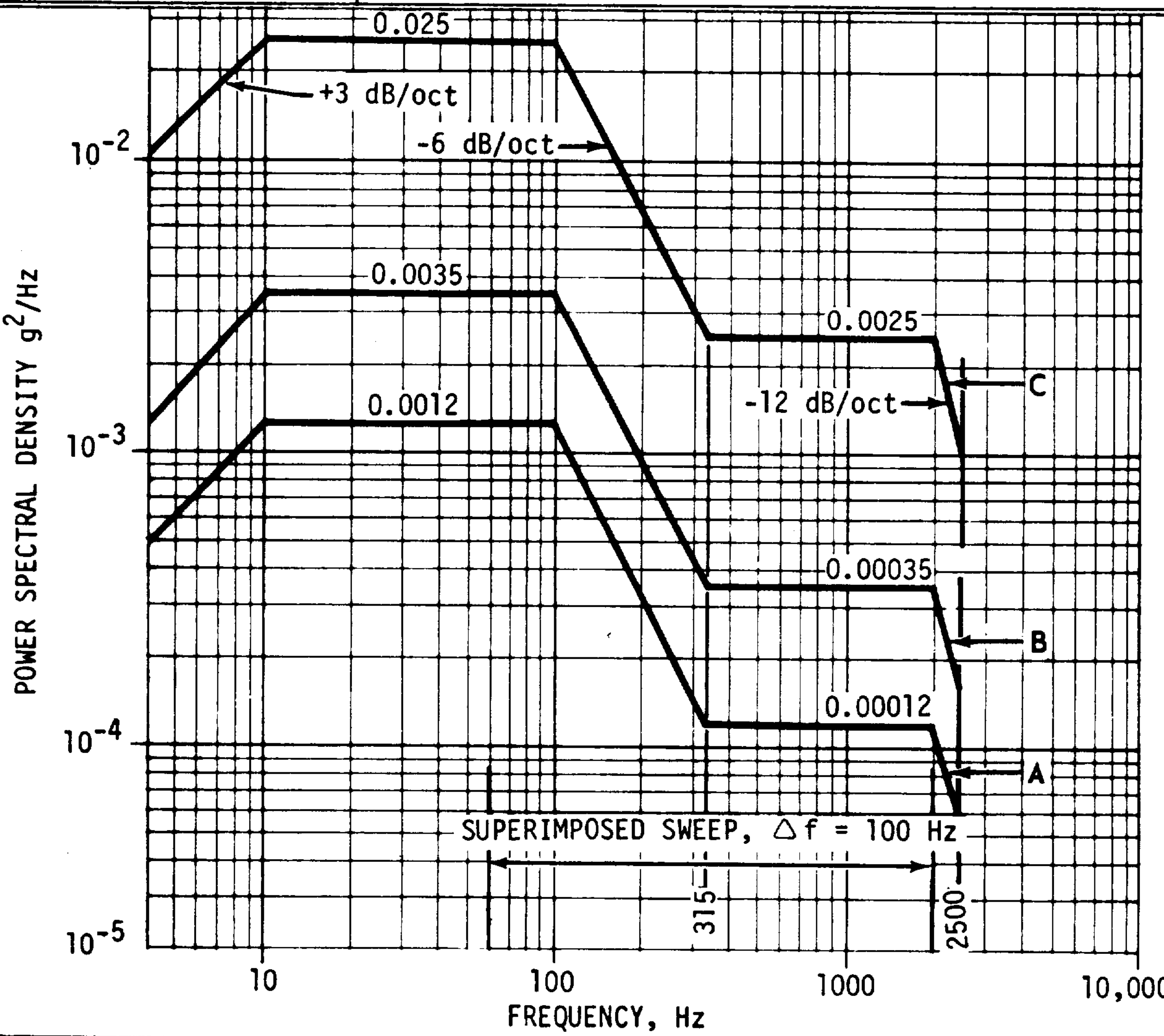
RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.1.2
SHOCK MOUNTED FLOORS. COMPARTMENTS 1A, 7A, 8A, 9A AND 10A
X AND Y - DIRECTIONS



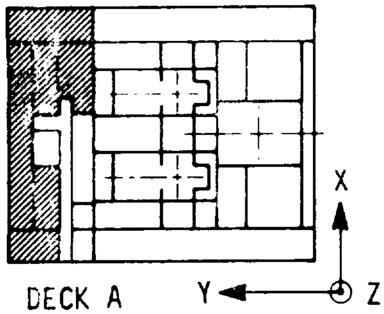
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	0.6
B	Lift-off Steady State Until Umbilical Disconnect	0.01	0.7
C	Lift-off Peak	0.01	1.3



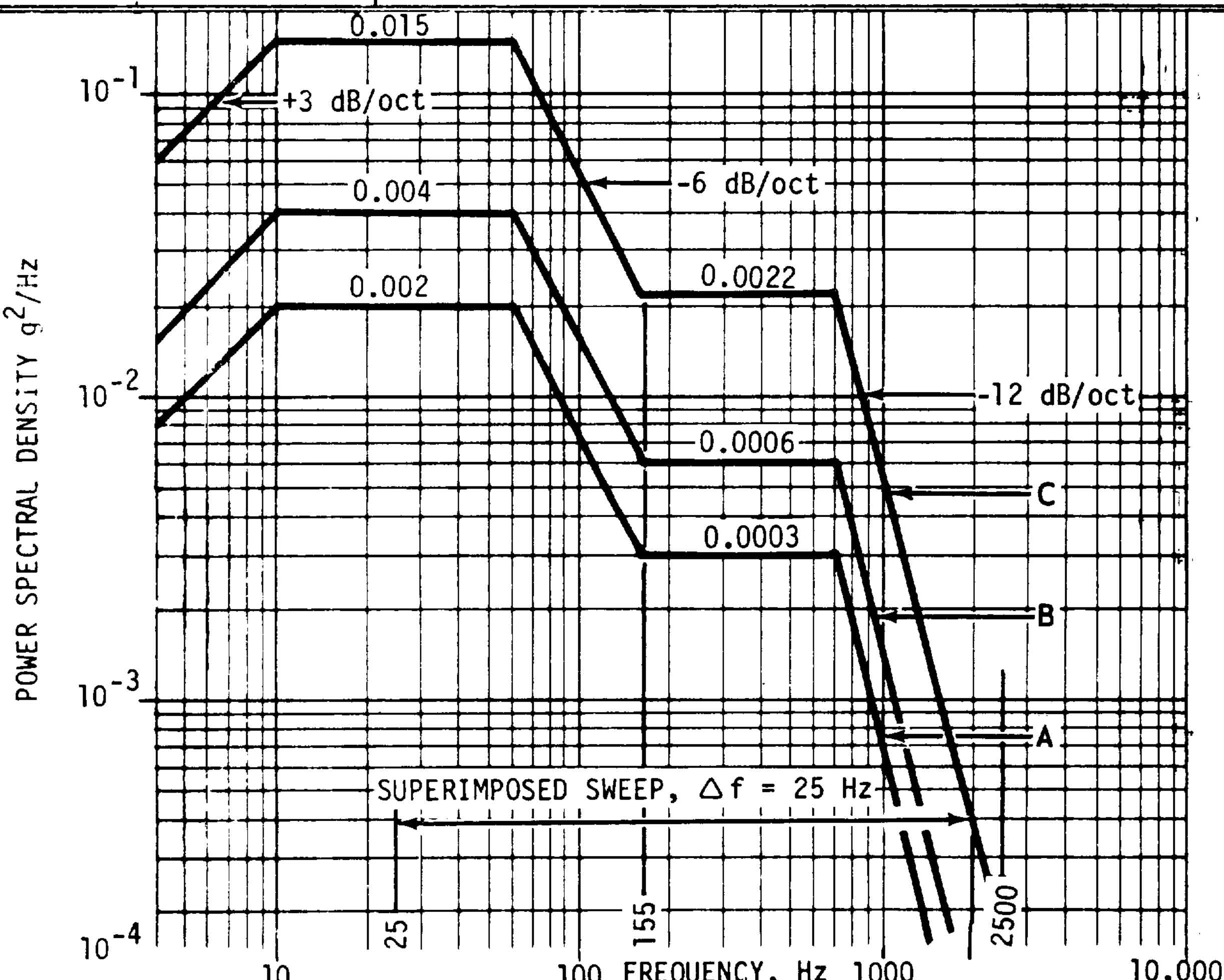
RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.1.2
SHOCK MOUNTED FLOORS. COMPARTMENTS 1A, 7A, 8A, 9A, AND 10A
Z-DIRECTION



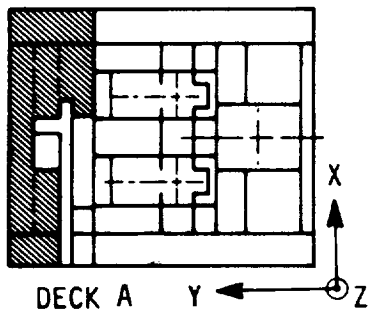
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.2
B	Lift-off Steady State Until Umbilical Disconnect	0.01	1.5
C	Lift-off Peak	0.02	3.3



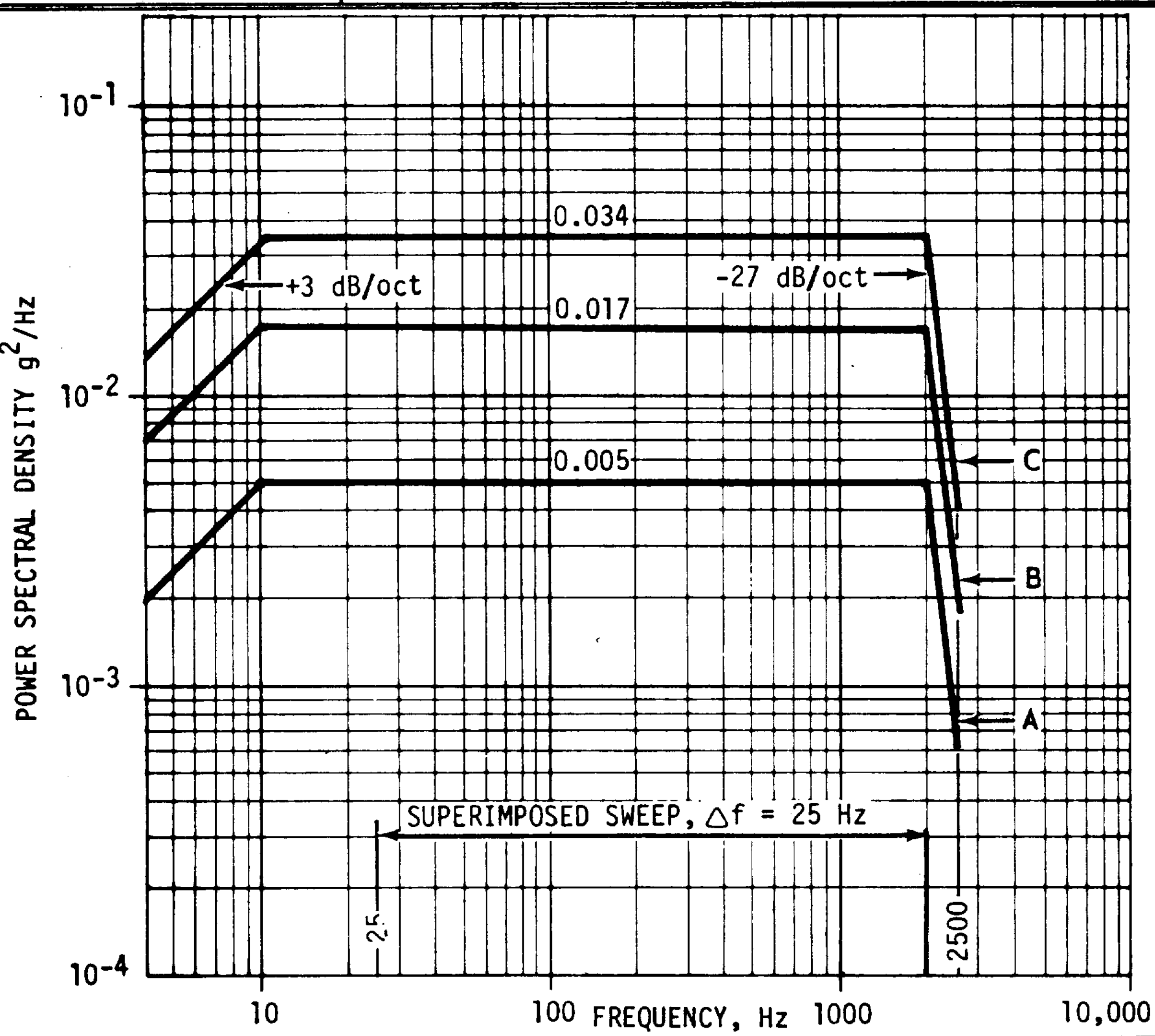
RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.2
MAIN FLOOR BEAMS SUPPORTING SHOCK-MOUNTED FLOORS.
X AND Y - DIRECTIONS



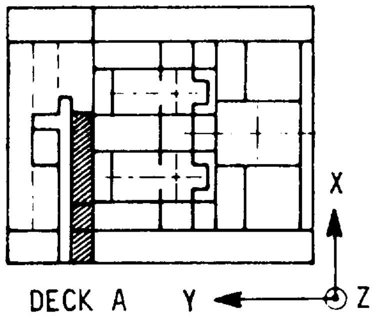
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	0.8
B	Lift-off Steady State Until Umbilical Disconnect	0.01	1.0
C	Lift-off Peak	0.2	1.9



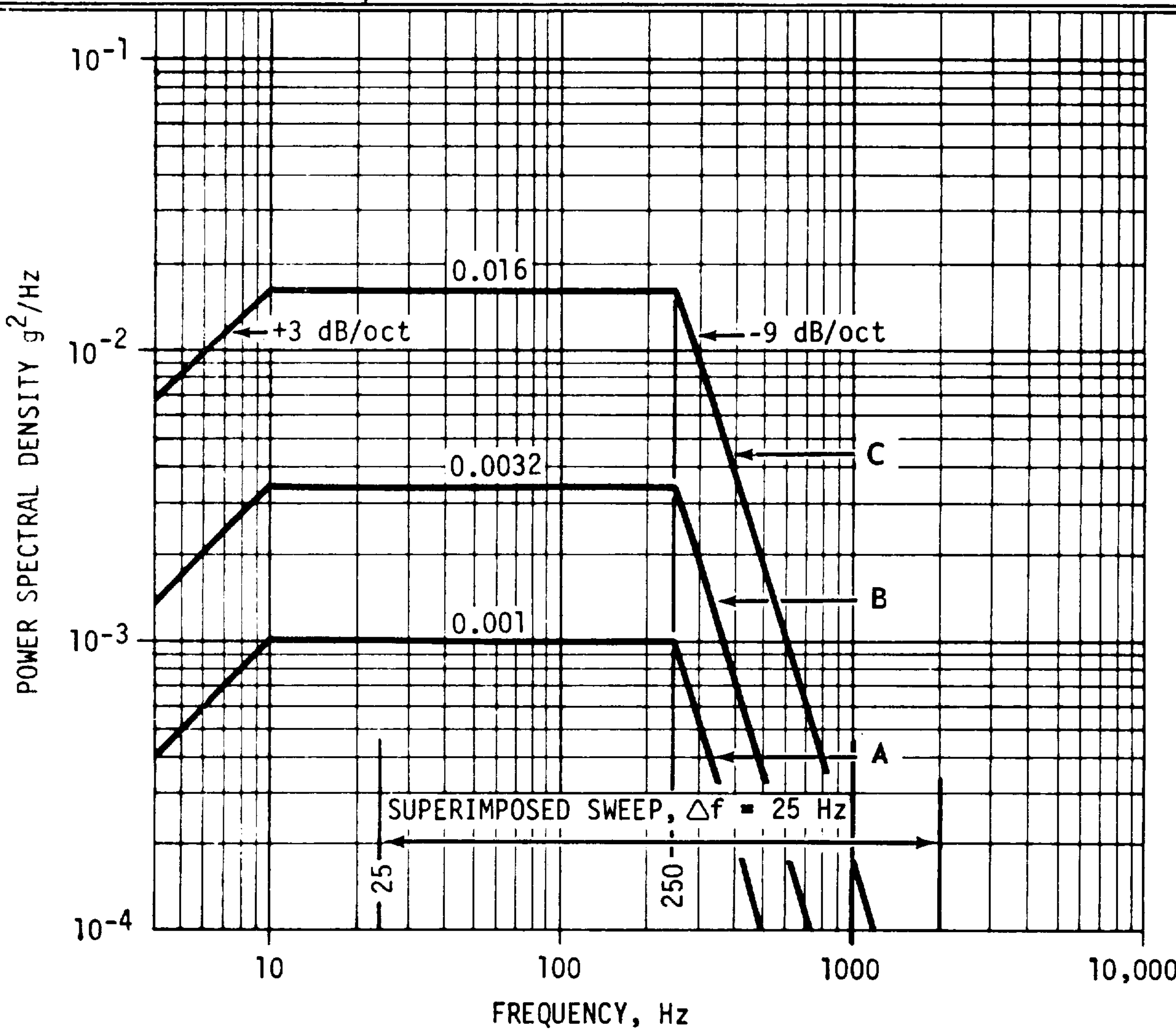
RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.2
MAIN FLOOR BEAMS SUPPORTING SHOCK-MOUNTED FLOORS.
Z - DIRECTION



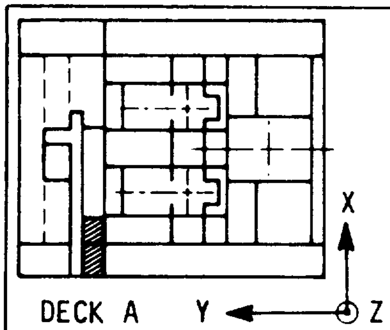
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.04	3.5
B	Lift-off Steady State Until Umbilical Disconnect	0.2	6.5
C	Lift-off Peak	0.35	9.1



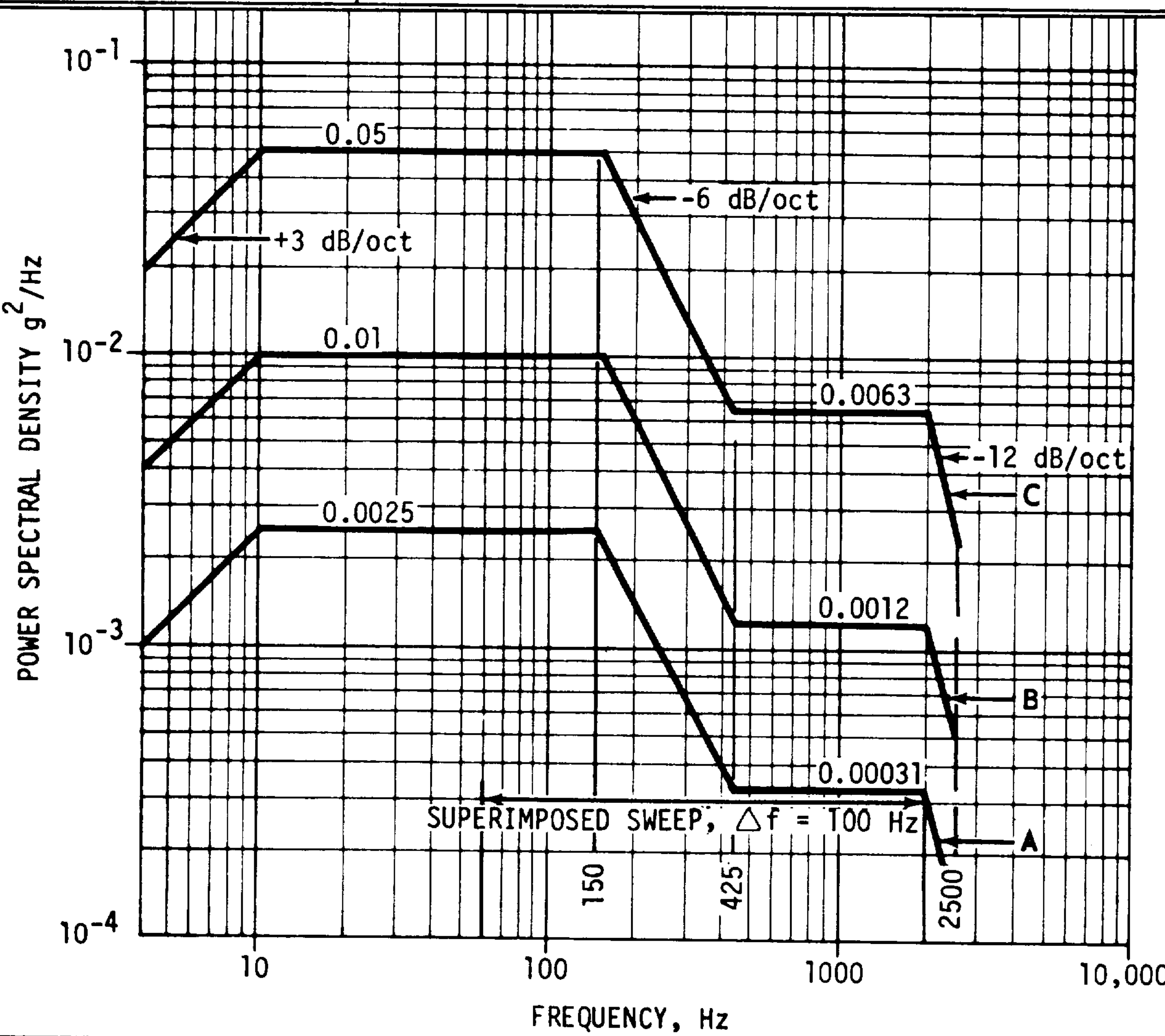
RANDOM VIBRATION ENVIRONMENT
ZONES 2.2.2.1 AND 2.2.2.2
ELEVATED FLOOR STRUCTURE
COMPARTMENTS 18A, 19A, 21A
X AND Y DIRECTIONS



Sym.	Launch Stage	Sweep △ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	0.9
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.3
C	Lift-off Peak	0.05	2.7

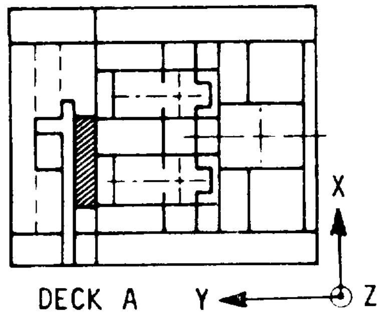


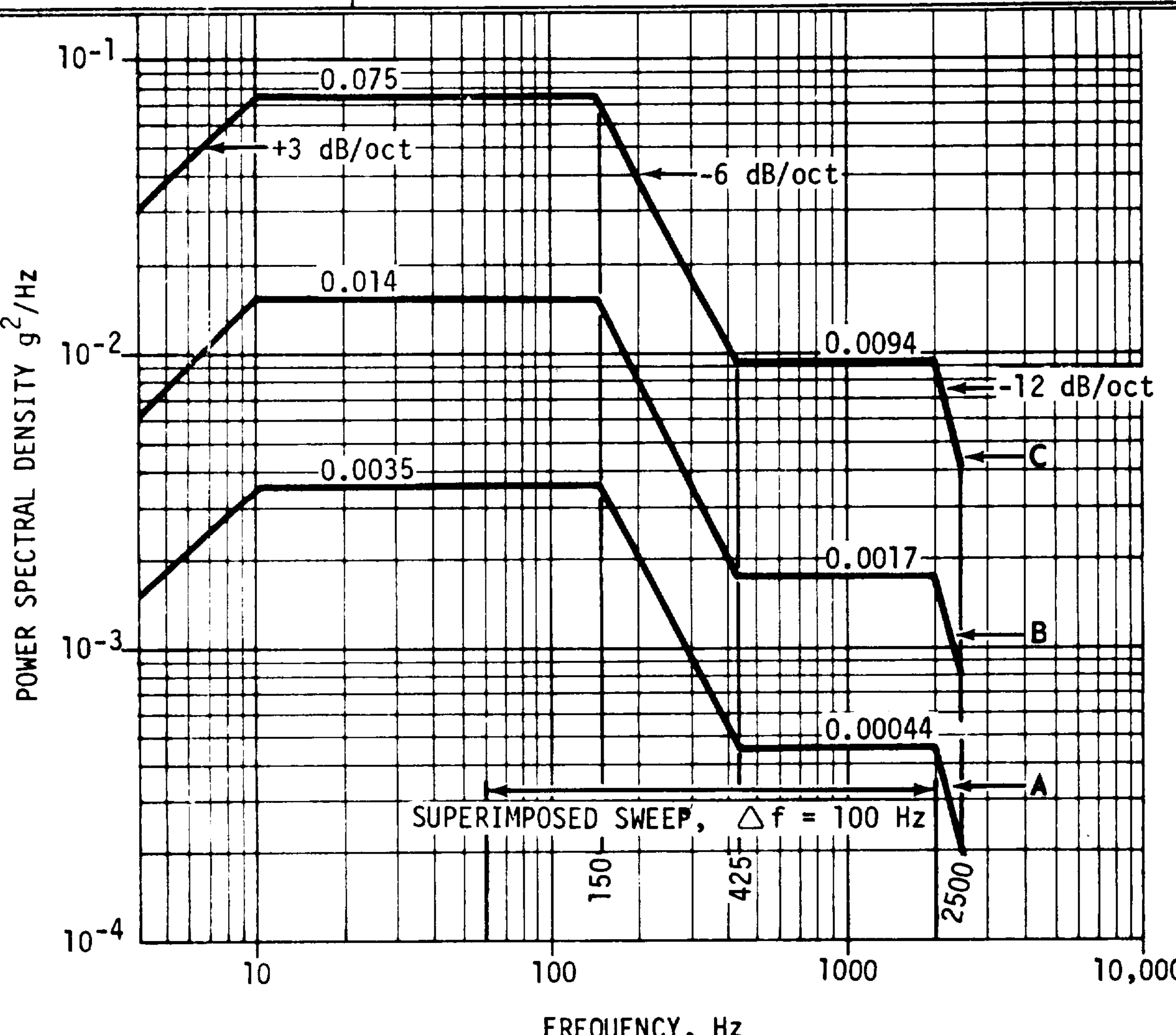
RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.2.1
ELEVATED FLOOR STRUCTURE
COMPARTMENTS 18A, 19A
Z-DIRECTION



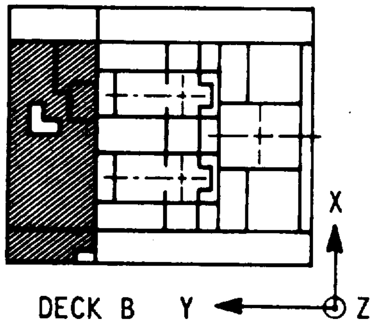
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.5
B	Lift-off Steady State Until Umbilical Disconnect	0.02	2.6
C	Lift-off Peak	0.05	5.4

RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.2.2
ELEVATED FLOOR STRUCTURE COMPARTMENT 21A
Z-DIRECTION

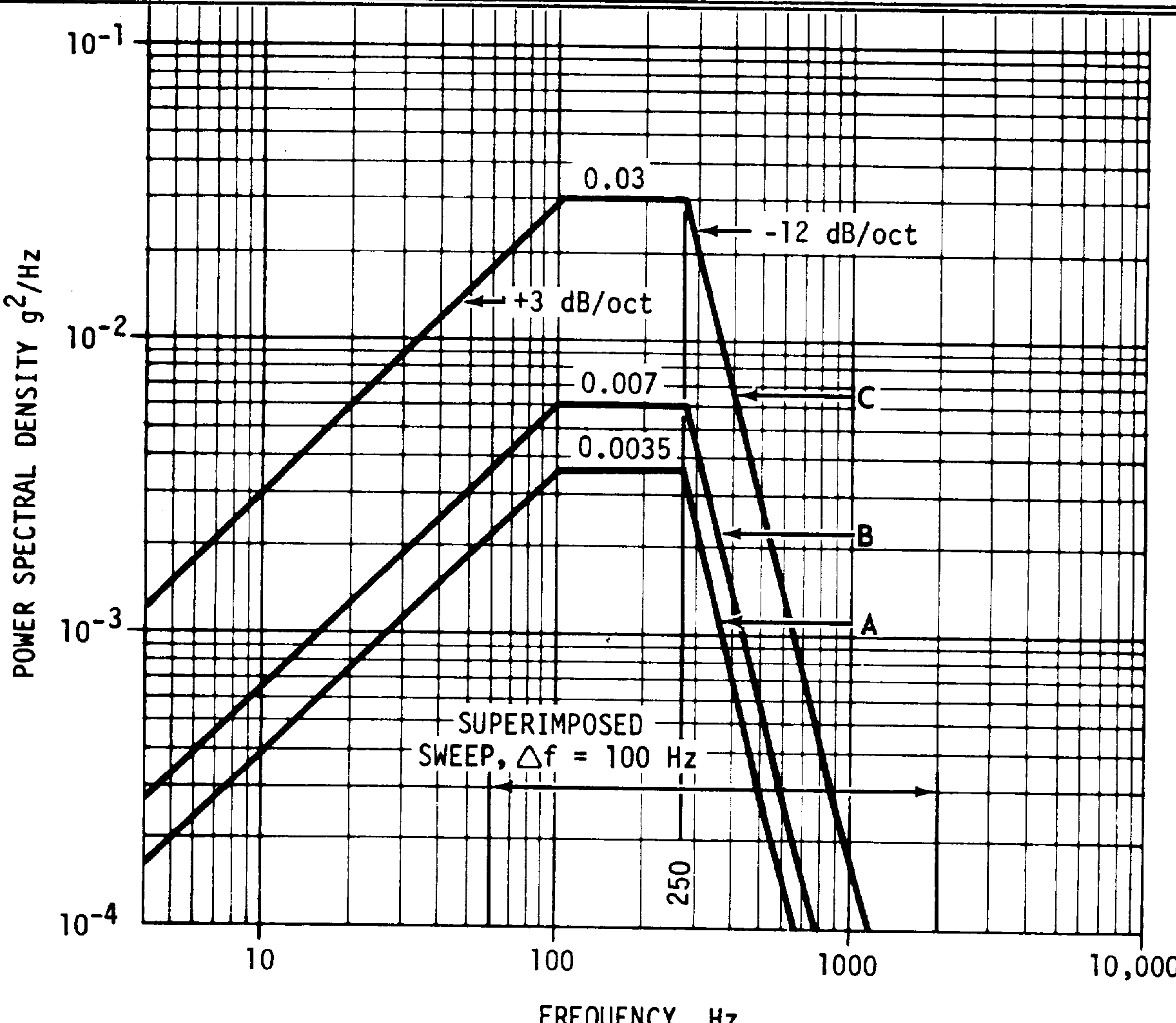




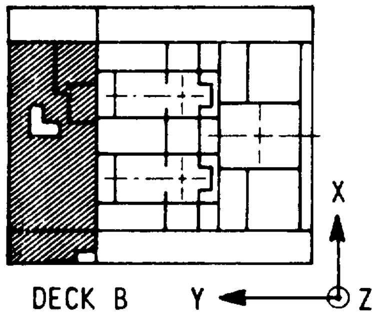
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.7
B	Lift-off Steady State Until Umbilical Disconnect	0.02	2.9
C	Lift-off Peak	0.05	6.4



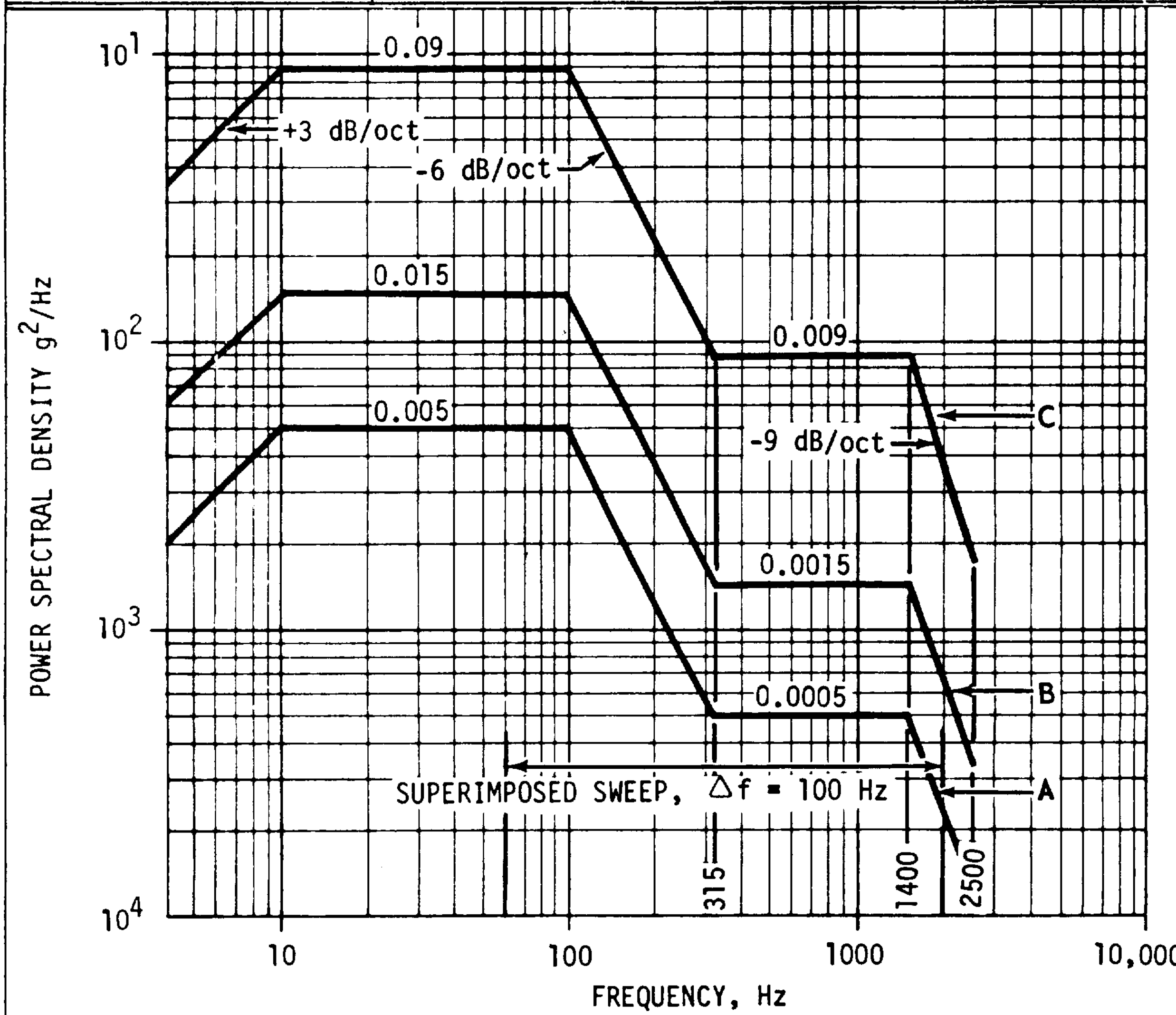
RANDOM VIBRATION ENVIRONMENT
ZONE 2.3.1
SHOCK MOUNTED FLOORS - COMPARTMENTS 7B, 8B, 9B, 10B, 15B, 21B, AND 22B
X AND Y DIRECTIONS



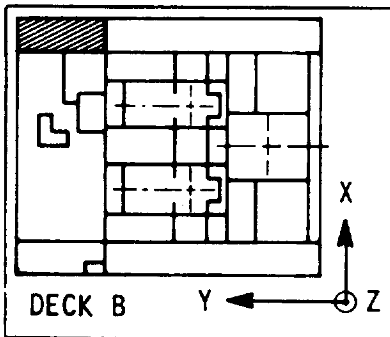
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.4
B	Lift-off Steady State Until Umbilical Disconnect	0.02	2.0
C	Lift-off Peak	0.03	3.4



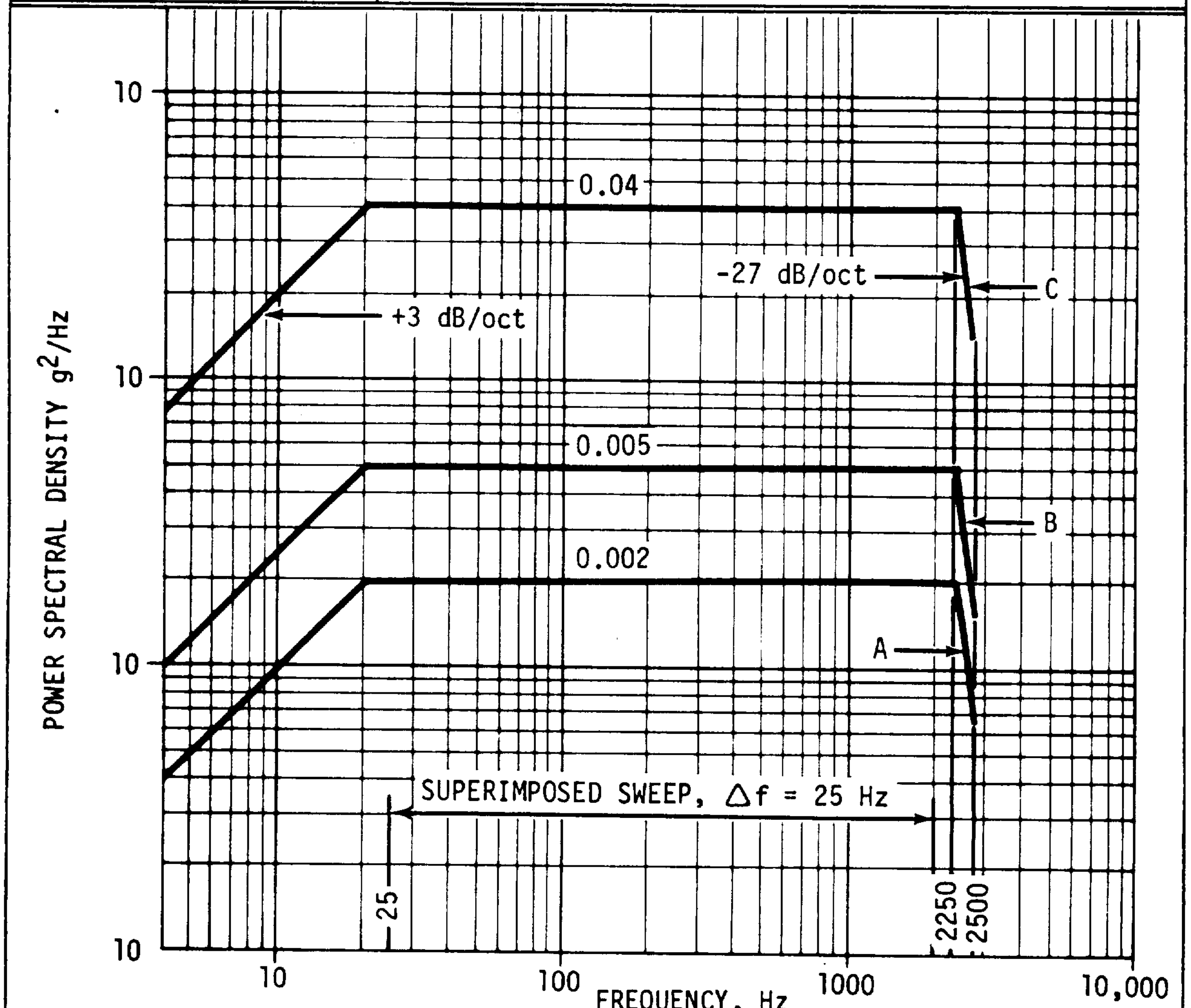
RANDOM VIBRATION ENVIRONMENT
ZONE 2.3.1
SHOCK MOUNTED FLOORS - COMPARTMENTS 7B, 8B, 9B, 10B, 15B, 21B, 22B
Z-DIRECTION



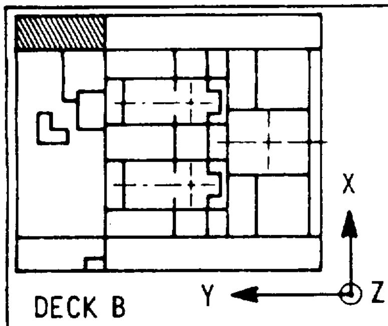
Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.9
B	Lift-off Steady State Until Umbilical Disconnect	0.04	3.0
C	Lift-off Peak	0.05	5.8



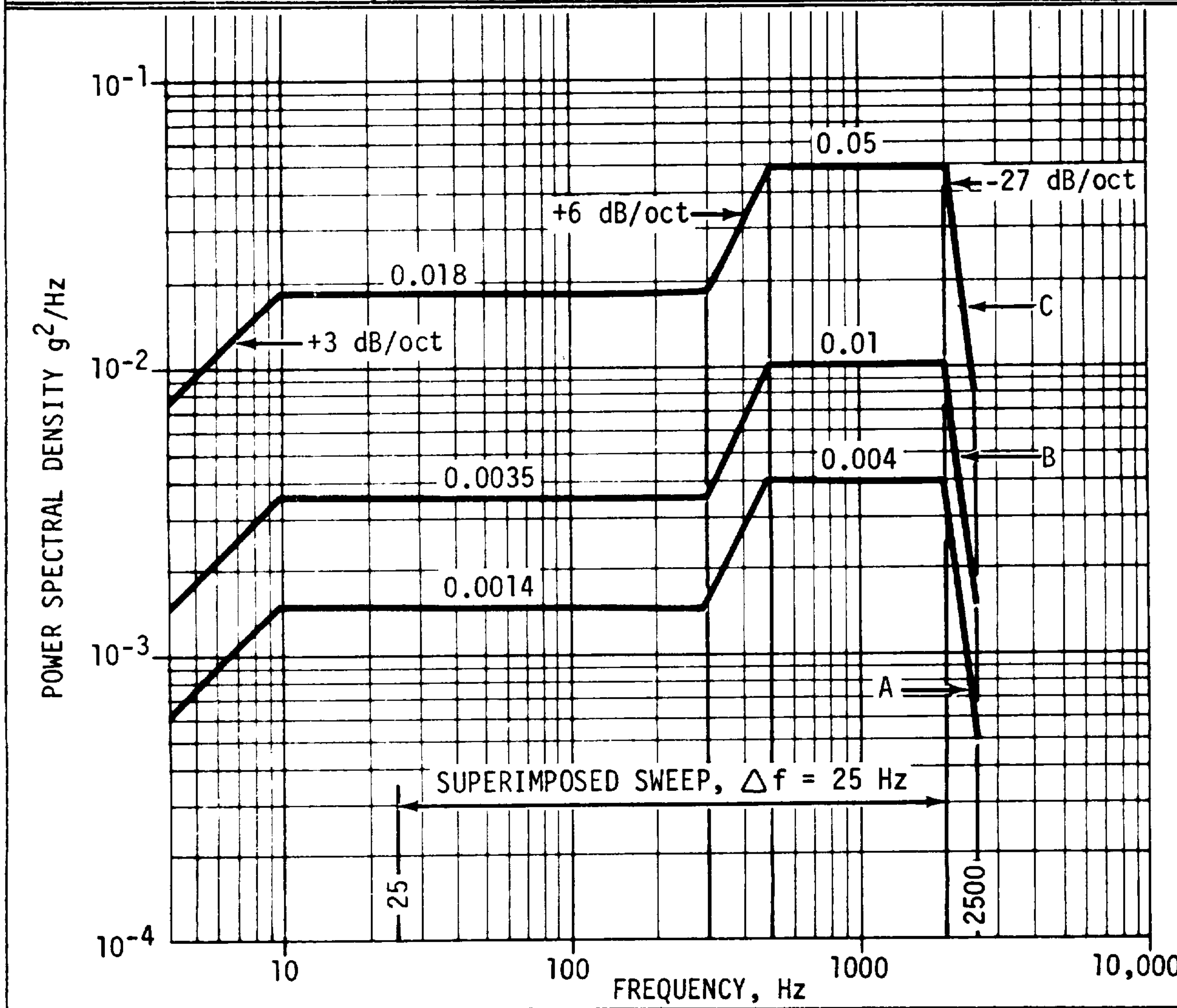
RANDOM VIBRATION ENVIRONMENT
ZONES 2,3.2 AND 2.3.2.1
MAIN FLOOR STRUCTURE AND ELEVATED FRAMING
COMPARTMENT 1B
X - DIRECTION



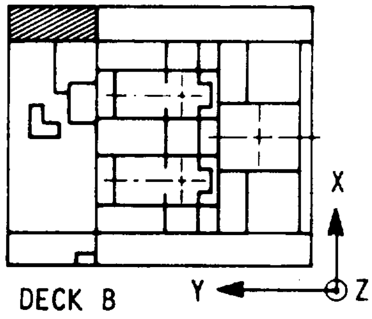
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	2.4
B	Lift-off Steady State Until Umbilical Disconnect	0.1	3.8
C	Lift-off Peak	0.2	10.0



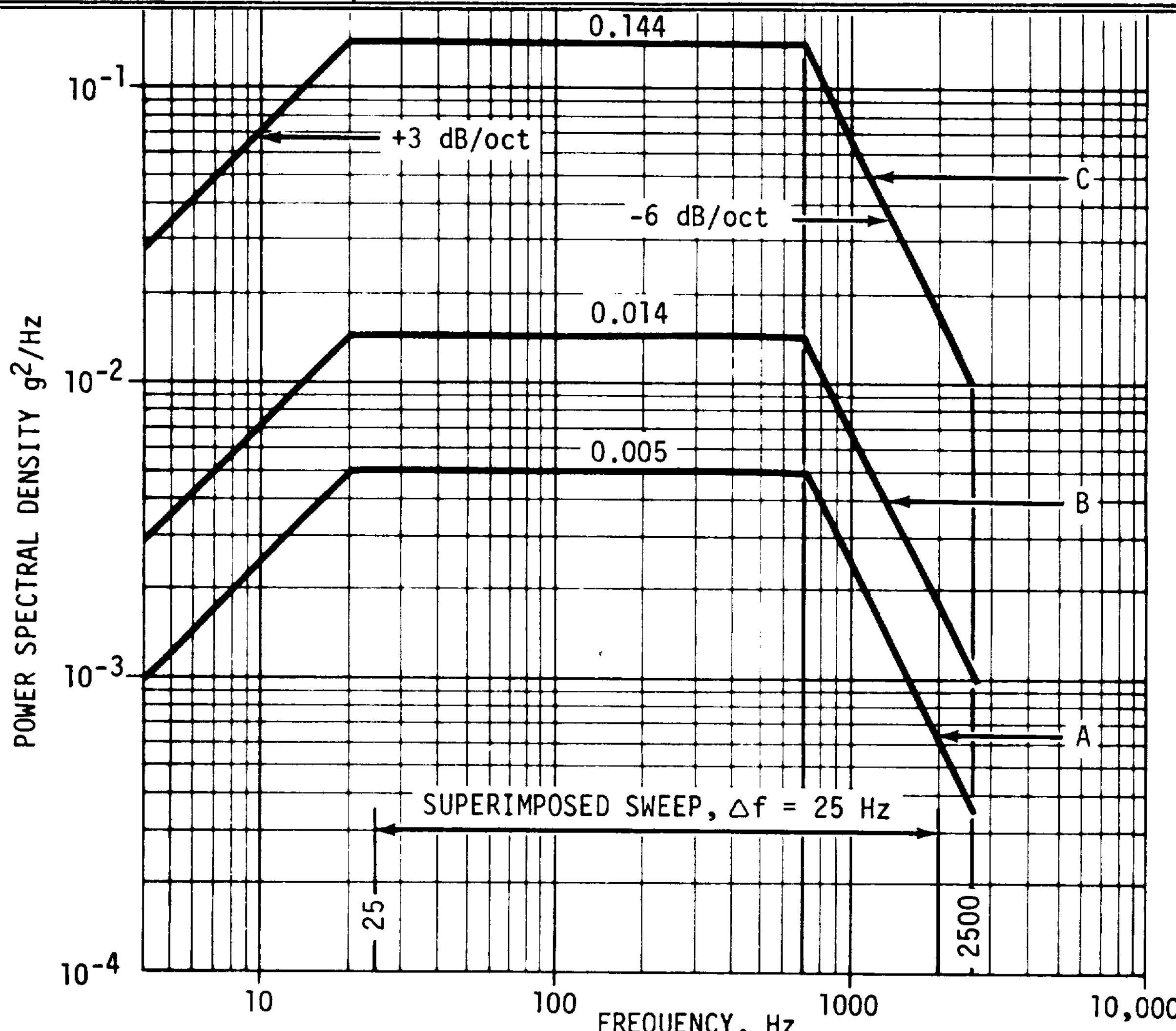
RANDOM VIBRATION ENVIRONMENT
ZONES 2.3.2 AND 2.3.2.1
MAIN FLOOR STRUCTURE AND ELEVATED
FRAMING. COMPARTMENT 1B
Y - DIRECTION



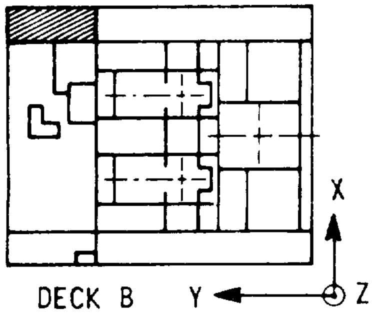
Sym.	Launch Stage	Sweep PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	2.9
B	Lift-off Steady State Until Umbilical Disconnect	0.04	4.5
C	Lift-off Peak	0.3	10.2



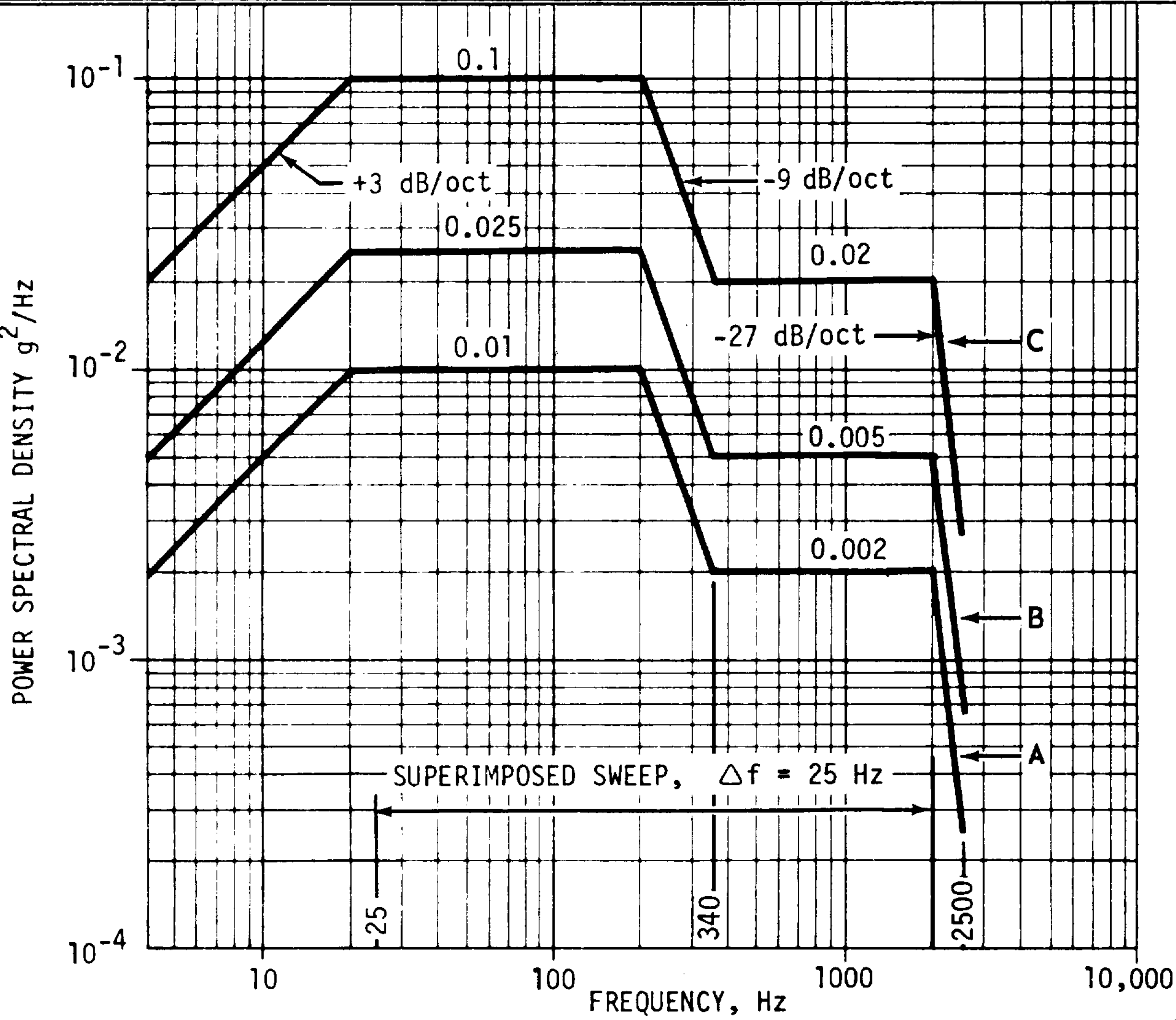
RANDOM VIBRATION ENVIRONMENT
ZONE 2.3.2
MAIN FLOOR STRUCTURE. COMPARTMENT 1B
Z - DIRECTION



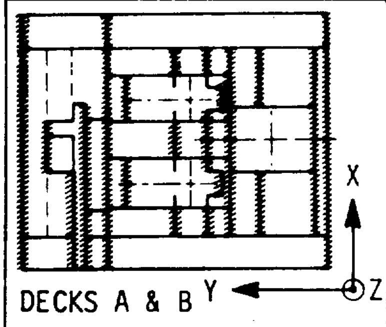
Sym.	Launch Stage	Sweep PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	2.5
B	Lift-off Steady State Until Umbilical Disconnect	0.02	4.1
C	Lift-off Peak	0.25	13.4



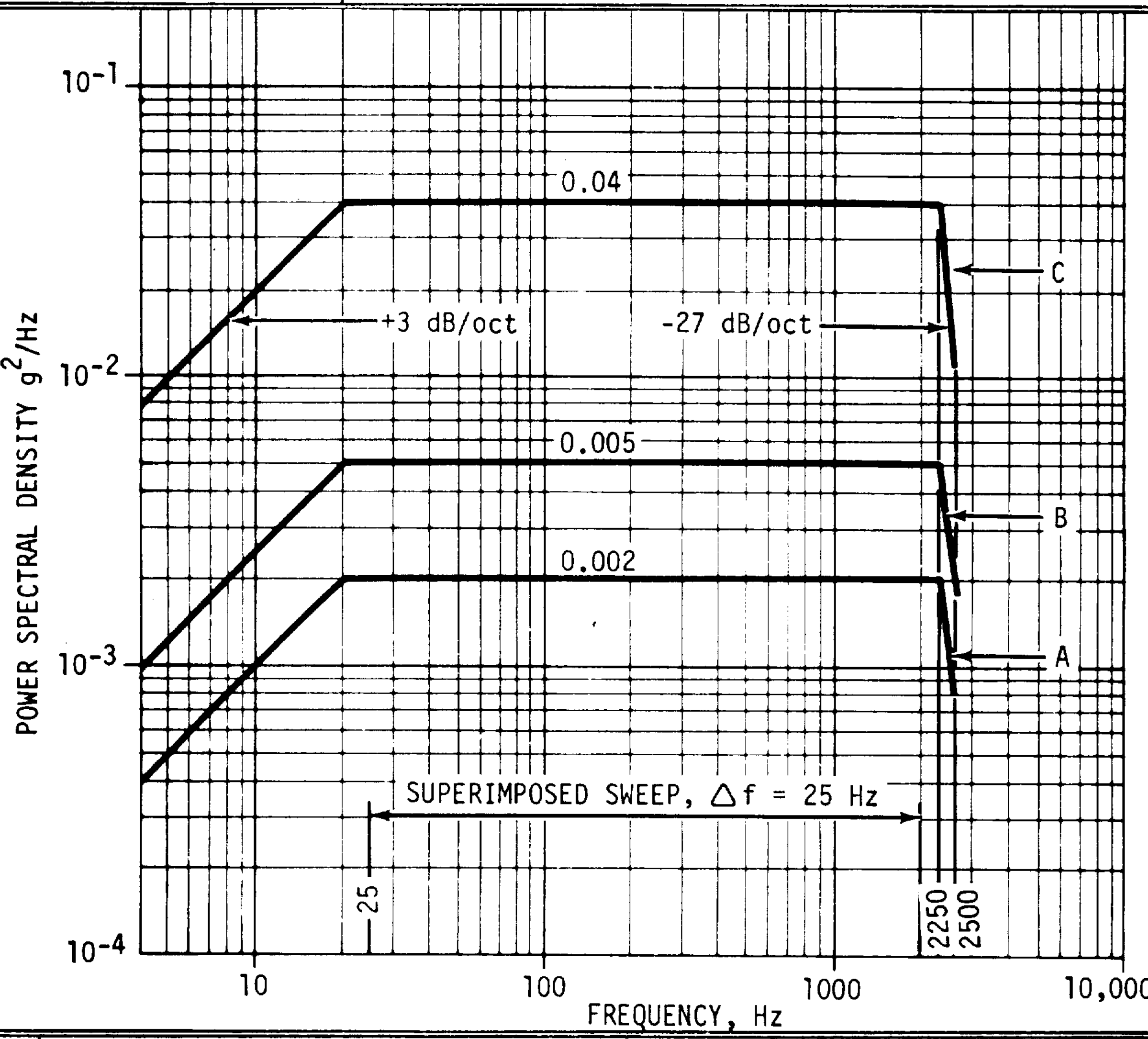
RANDOM VIBRATION ENVIRONMENT
ZONE 2.3.2.1
ELEVATED FRAMING. COMPARTMENT 1B
Z - DIRECTION



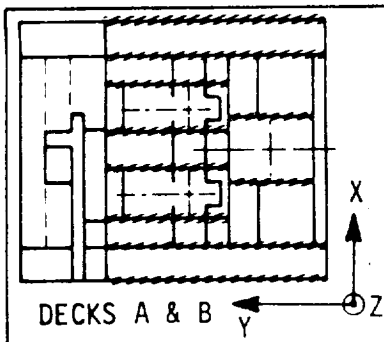
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	2.7
B	Lift-off Steady State Until Umbilical Disconnect	0.1	4.2
C	Lift-off Peak	0.25	8.3



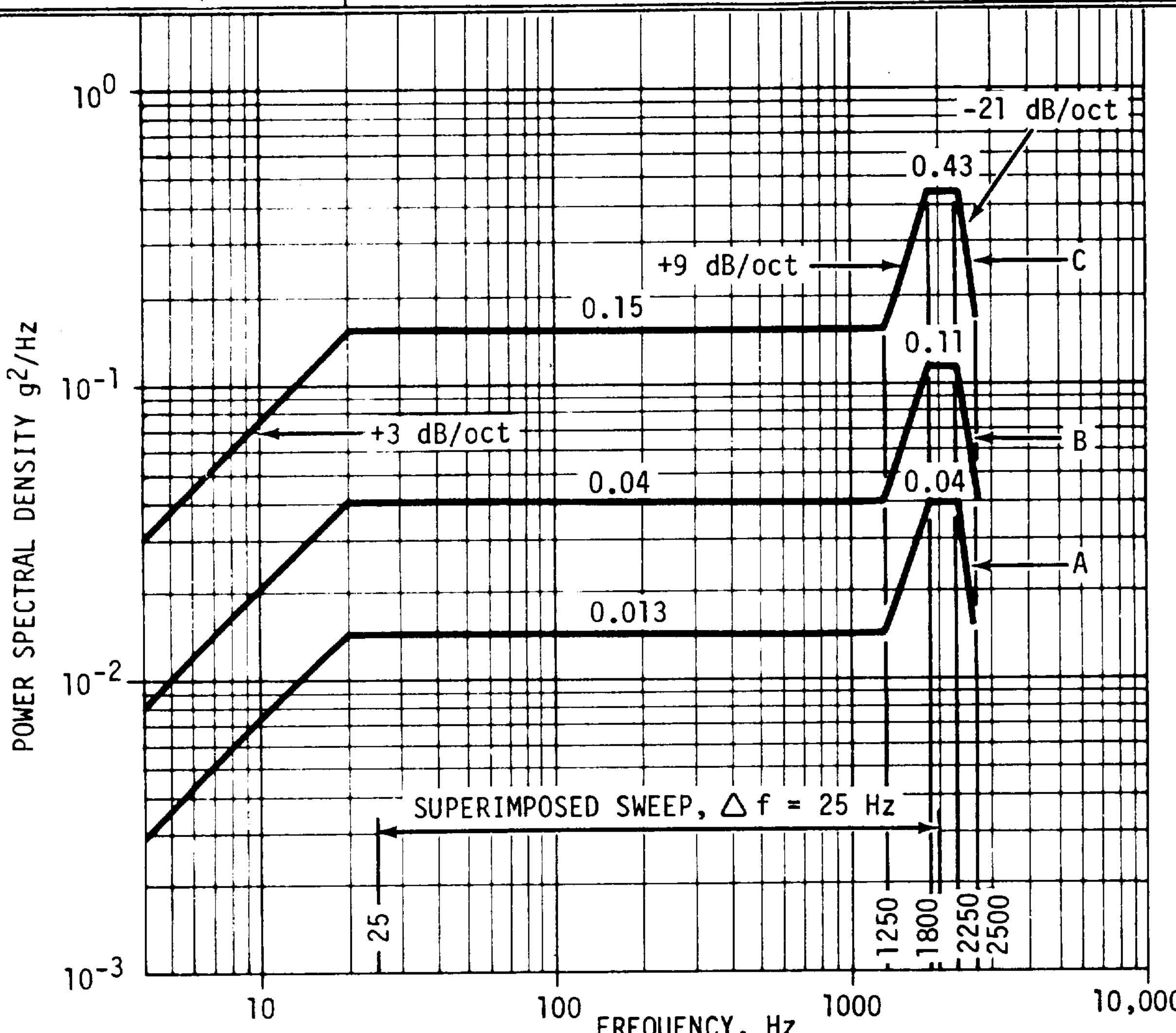
RANDOM VIBRATION ENVIRONMENT
GROUP SPECIFICATION.
ZONE 1.2, 1.3, 2.2 AND 2.3
GIRDER WEBS AND PARTITION WALLS
PARALLEL TO X-DIRECTION. DECKS A AND B
X - DIRECTION



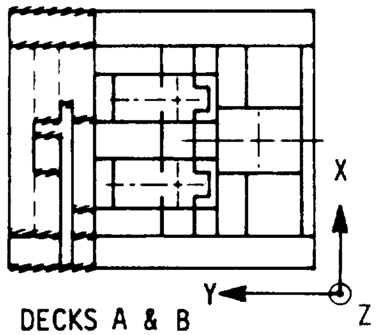
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	2.7
B	Lift-off Steady State Until Umbilical Disconnect	0.1	3.8
C	Lift-off Peak	0.25	10.1



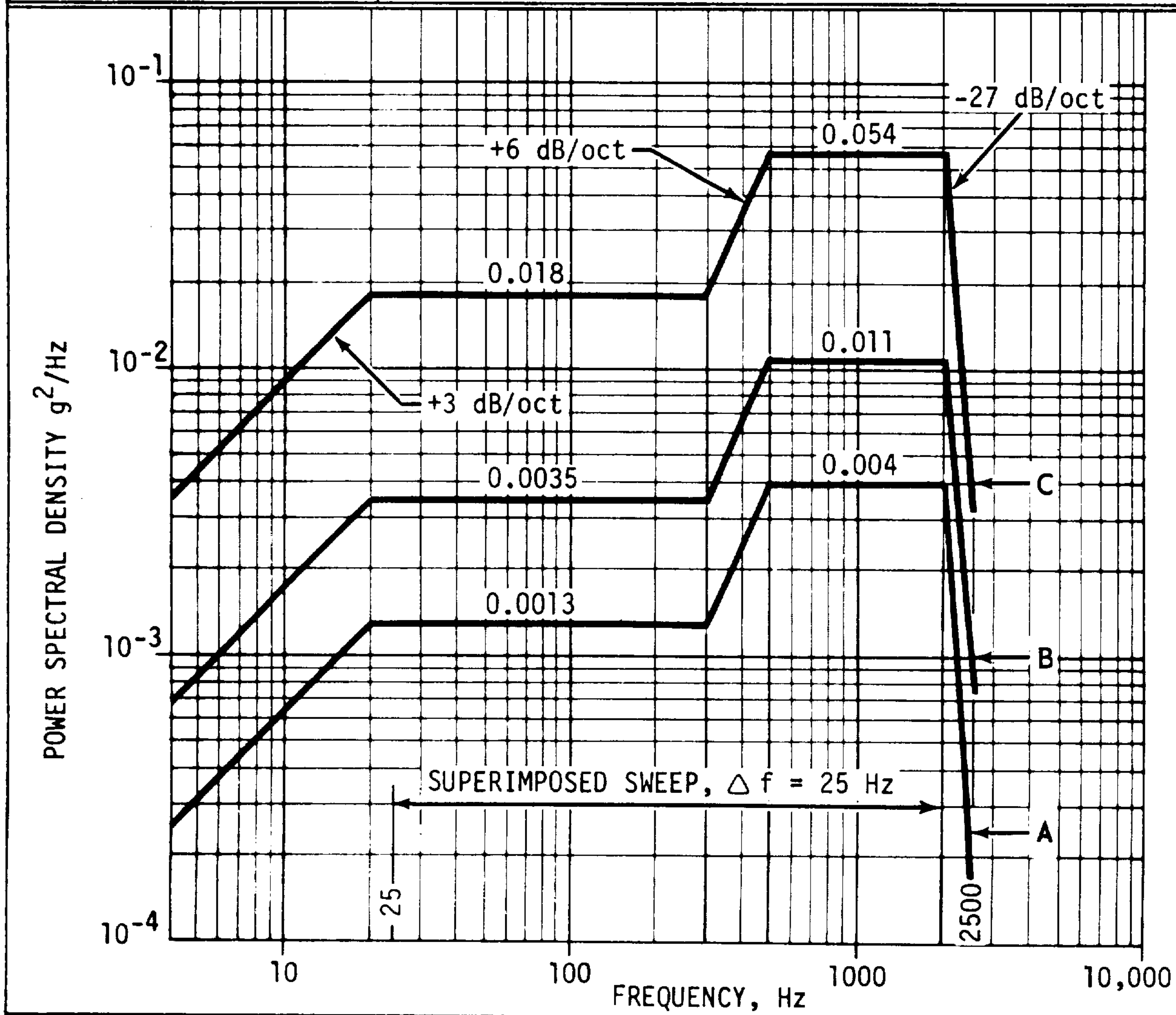
RANDOM VIBRATION ENVIRONMENT
GROUP SPECIFICATION.
ZONES 1.2 AND 1.3
GIRDER WEBS PARALLEL TO Y-DIRECTION.
DECKS A AND B
Y - DIRECTION



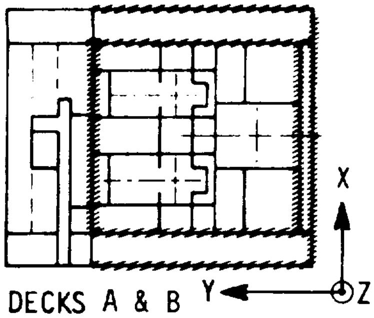
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	7.6
B	Lift-off Steady State Until Umbilical Disconnect	0.2	12.7
C	Lift-off Peak	0.4	24.8



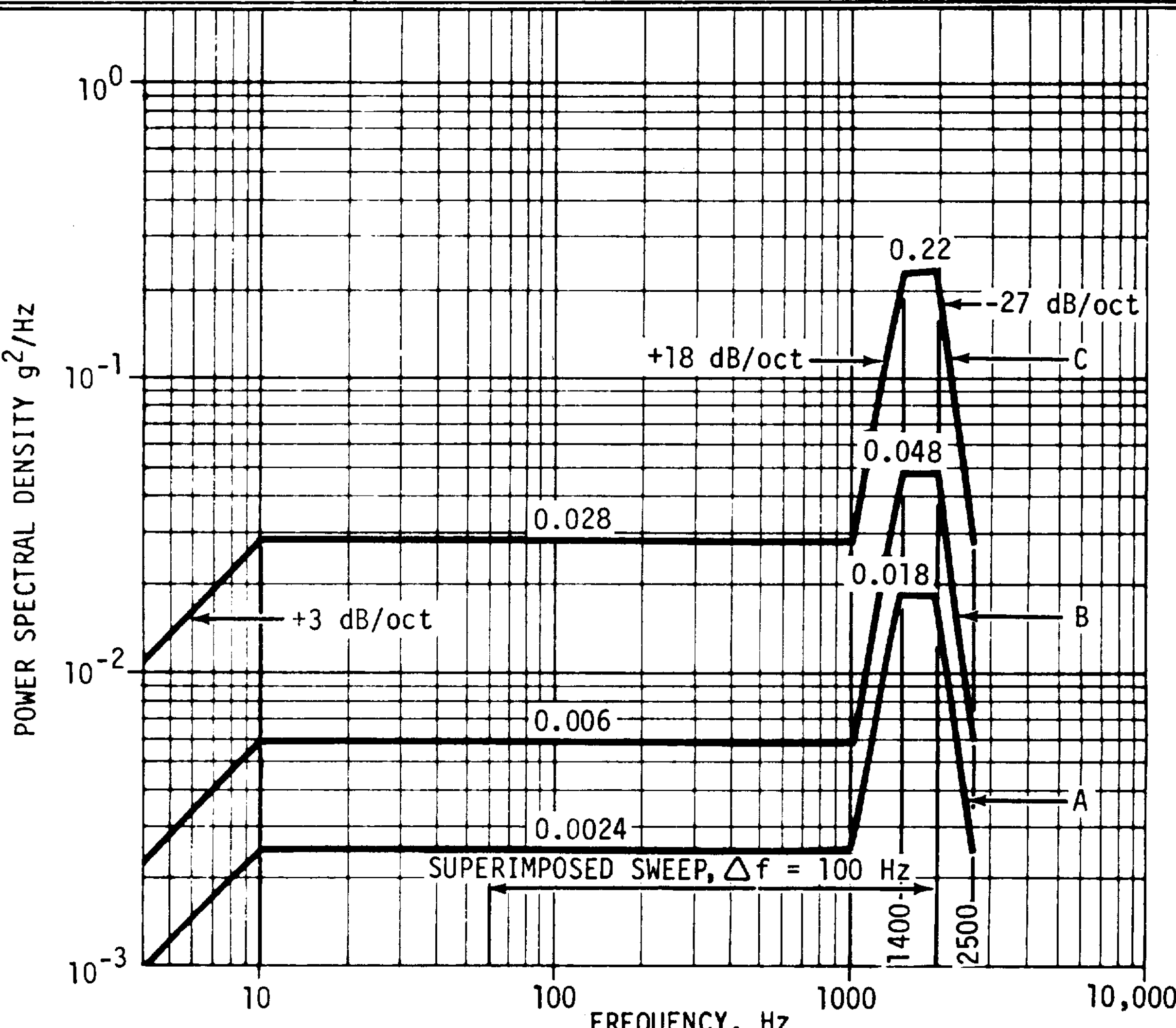
RANDOM VIBRATION ENVIRONMENT
GROUP SPECIFICATION
ZONES 2.2 AND 2.3
GIRDER WEBS AND PARTITION WALLS PARALLEL
TO Y-DIRECTION. DECKS A AND B
Y - DIRECTION



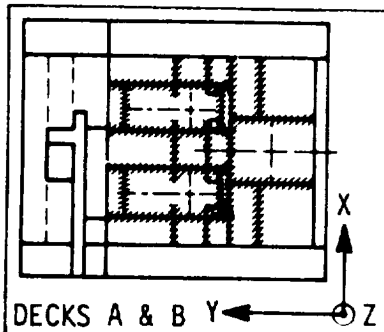
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	3.2
B	Lift-off Steady State Until Umbilical Disconnect	0.2	5.2
C	Lift-off Peak	0.4	10.8



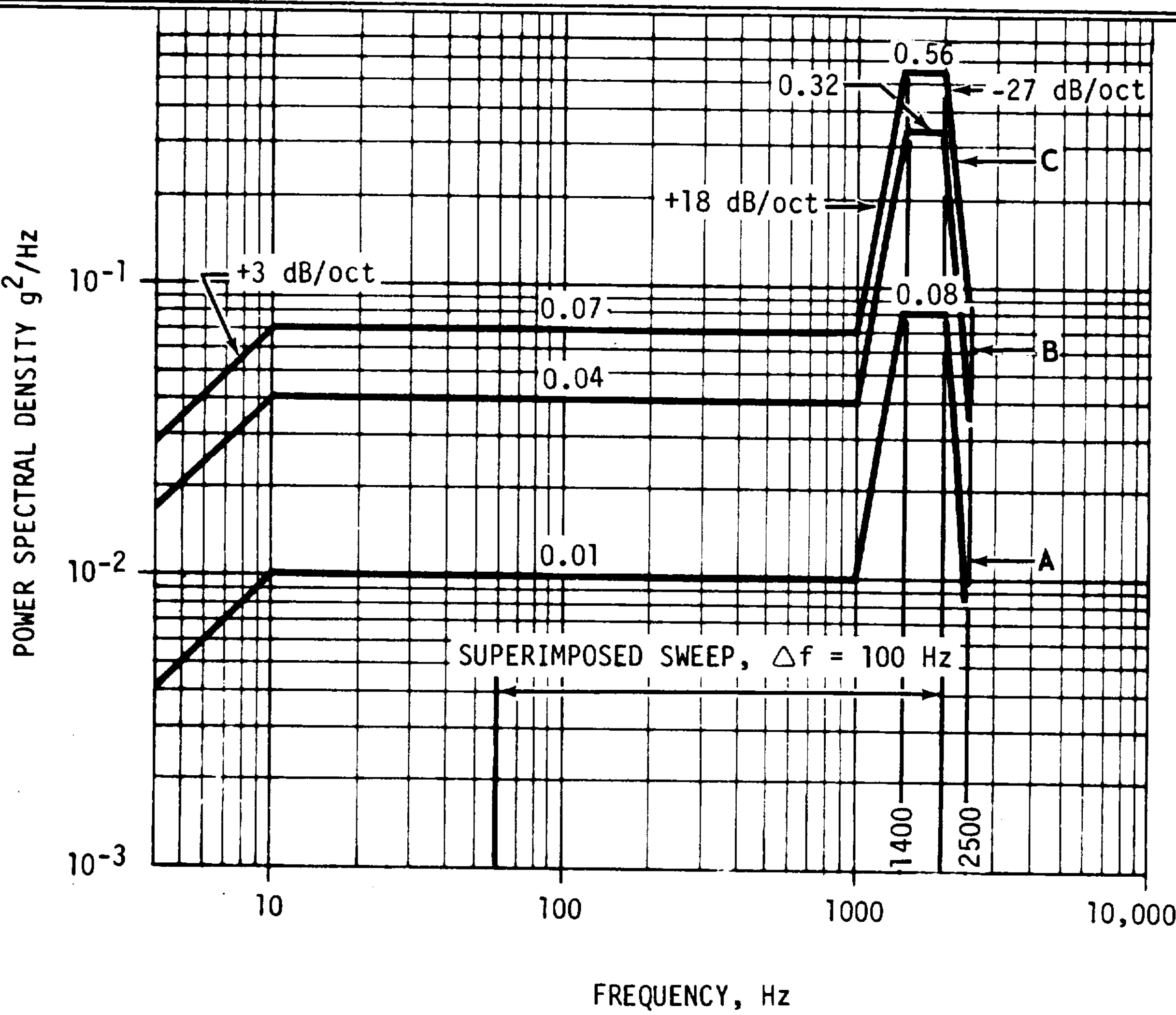
RANDOM VIBRATION ENVIRONMENT
GROUP SPECIFICATION.
ZONES 1.2 AND 1.3
GIRDER WEBS IN THE PERIPHERY OF
ZONES 1.2 AND 1.3, DECKS A AND B
Z - DIRECTION



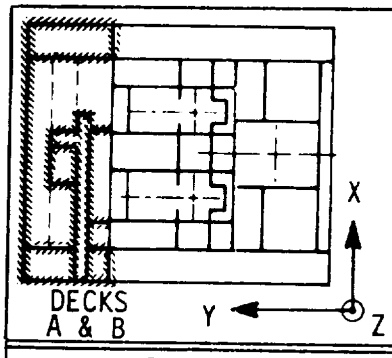
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	4.8
B	Lift-off Steady State Until Umbilical Disconnect	0.05	7.6
C	Lift-off Peak	0.50	17.3



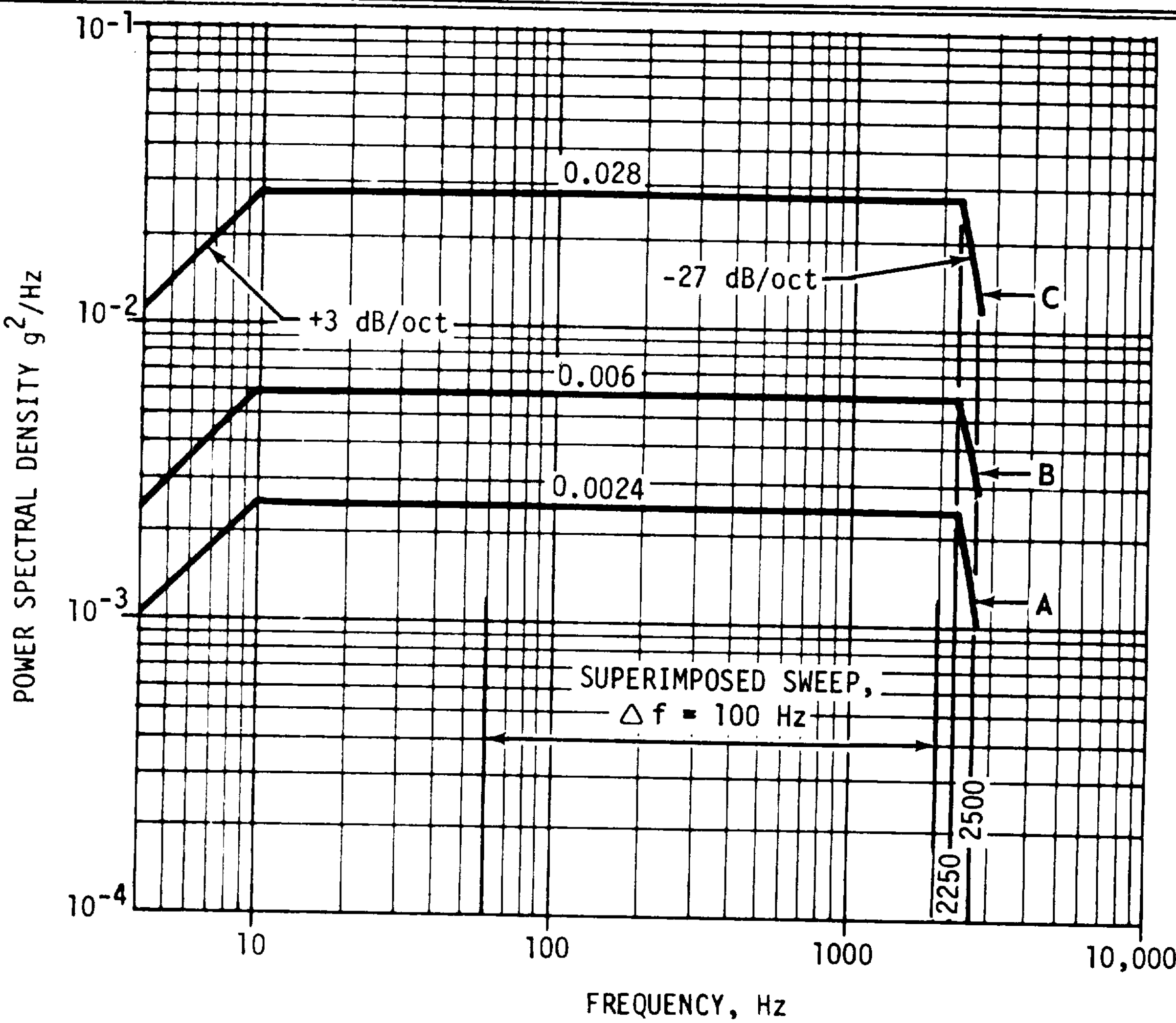
RANDOM VIBRATION ENVIRONMENT
GROUP SPECIFICATION
ZONES 1.2 AND 1.3
GIRDER WEBS IN THE CENTRAL PART OF ZONES
1.2 AND 1.3, DECKS A AND B
Z - DIRECTION



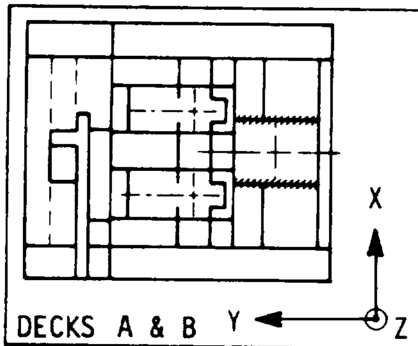
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.2	10.4
B	Lift-off Steady State Until Umbilical Disconnect	0.4	19.9
C	Lift-off Peak	1.0	27.0



RANDOM VIBRATION ENVIRONMENT
GROUP SPECIFICATION
ZONES 2.2 AND 2.3
GIRDER WEBS AND PARTITION WALLS.
Z - DIRECTION

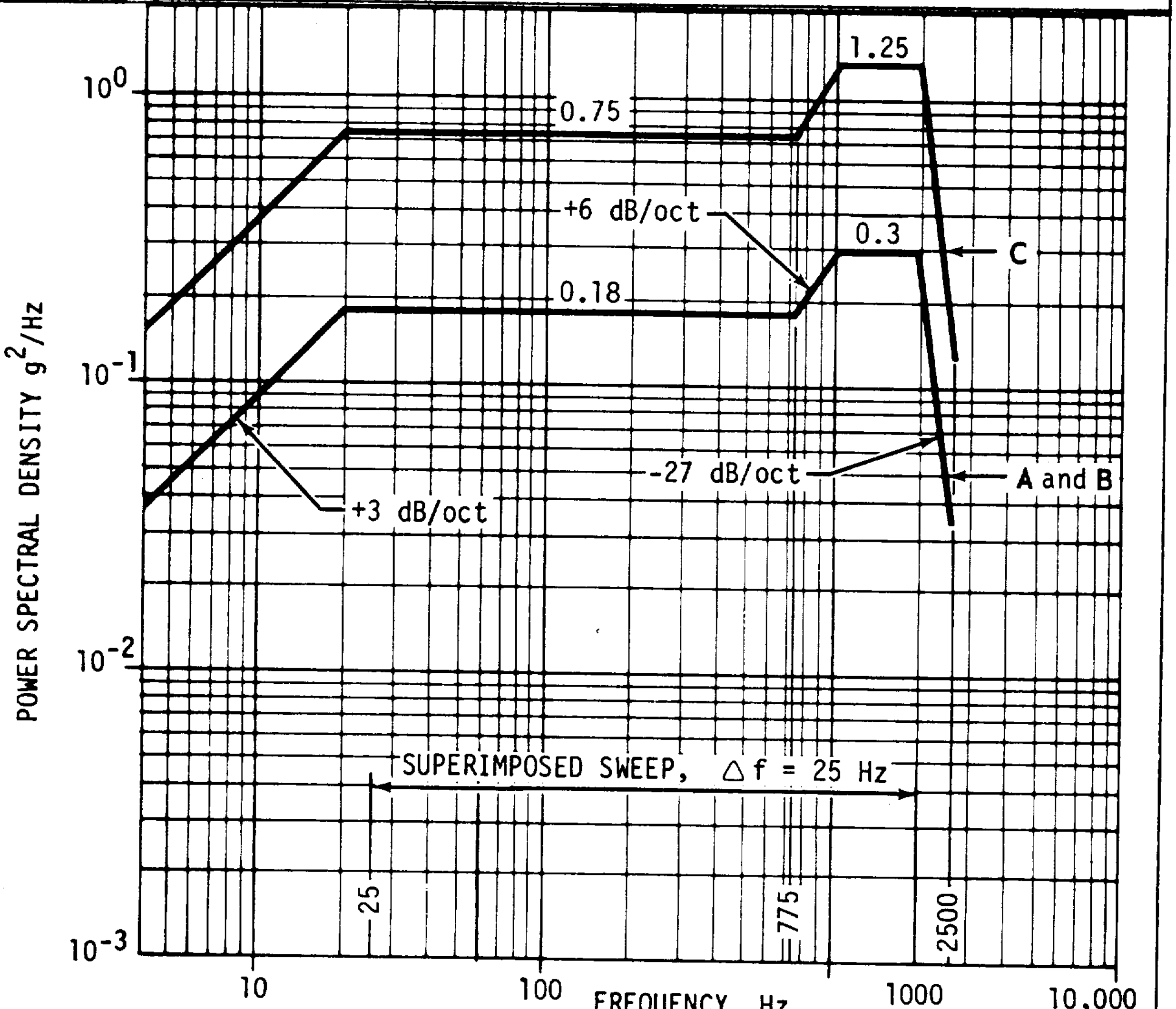


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	2.8
B	Lift-off Steady State Until Umbilical Disconnect	0.05	4.4
C	Lift-off Peak	0.2	9.3

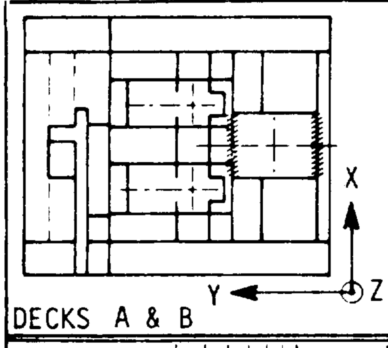


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.3 AND 1.3.3
GIRDER WEB STIFFENER
X-DIRECTION

NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION

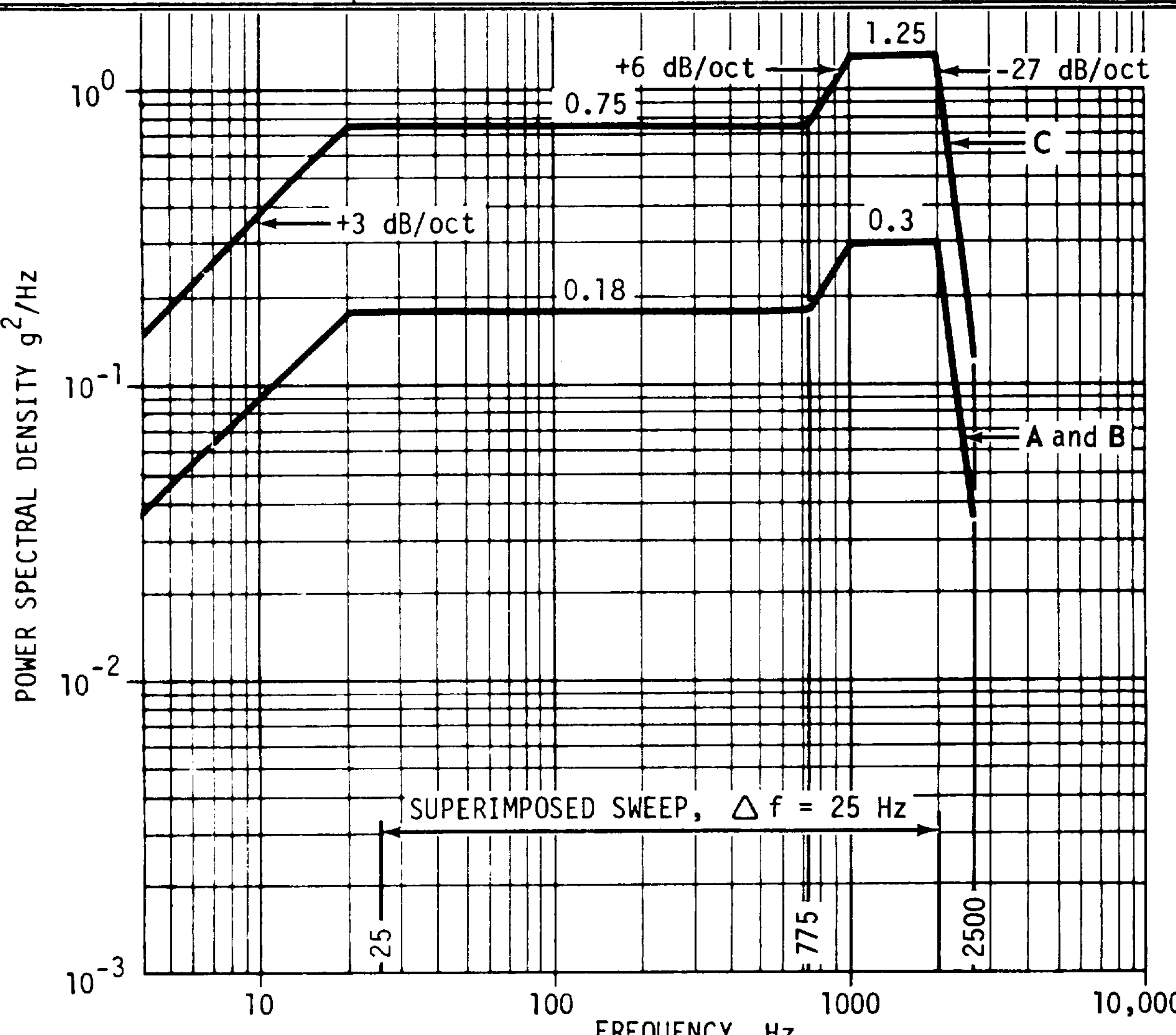


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	1.0	23.8
B	Lift-off Steady State Until Umbilical Disconnect	1.0	23.8
C	Lift-off Peak	1.0	48.2

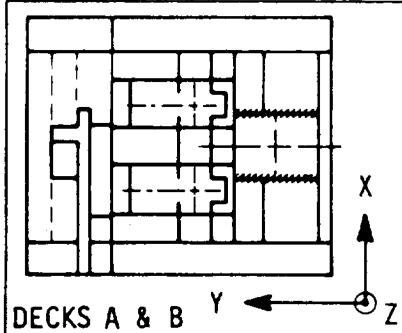


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.3 AND 1.3.3
GIRDER WEB STIFFENER
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

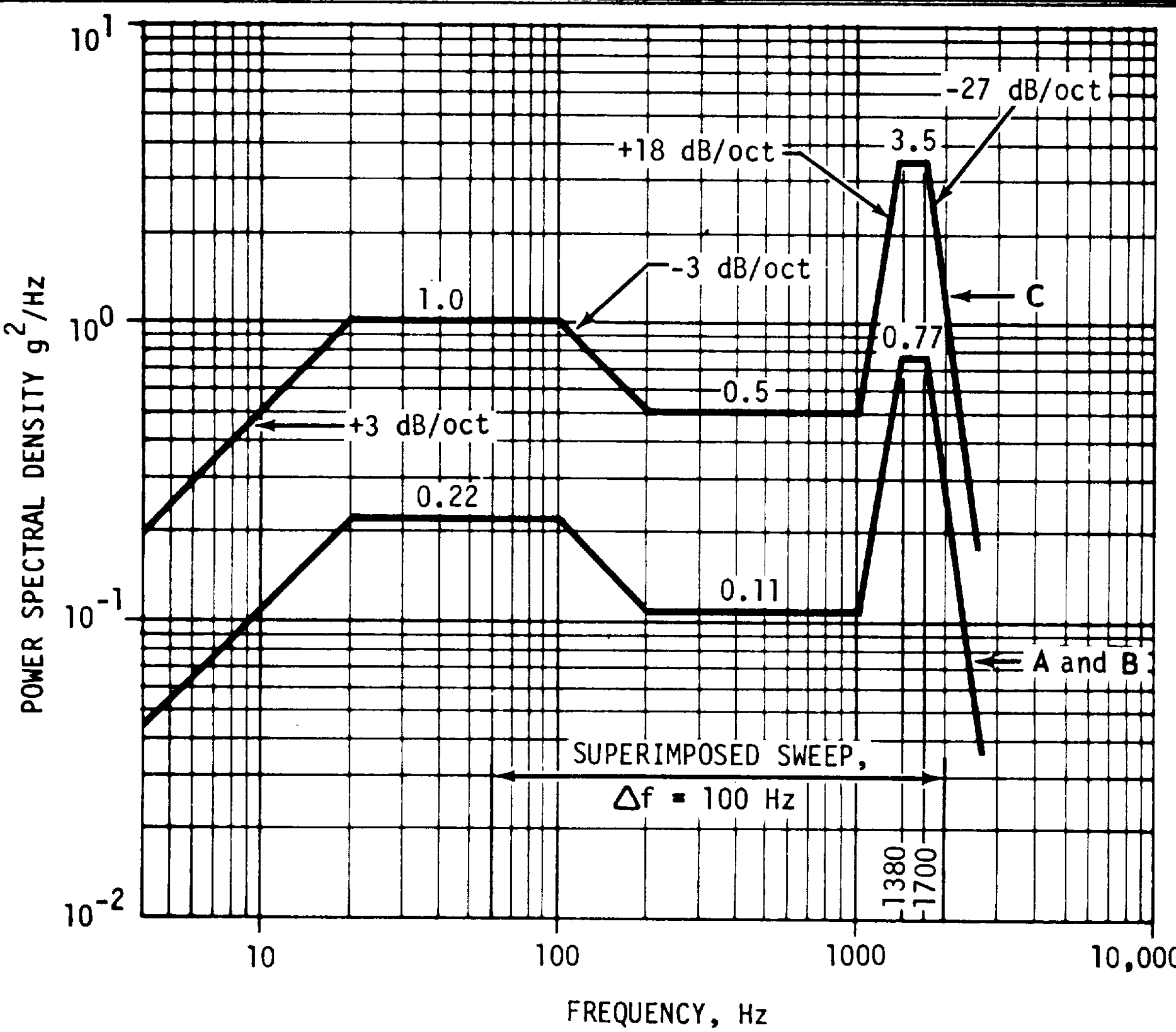


Sym.	Launch Stage	Sweep $\Delta PSD\ g^2/Hz$	Overall Level g_{rms}
A	Orbiter Holddown	1.0	23.8
B	Lift-off Steady State Until Umbilical Disconnect	1.0	23.8
C	Lift-off Peak	1.0	48.2

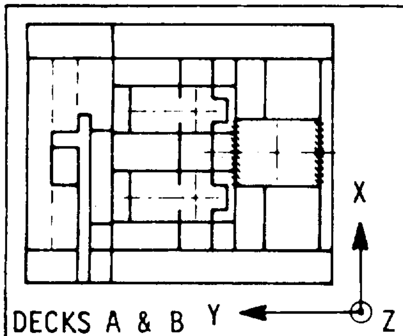


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.3.1 AND 1.3.3.1
GIRDER WEB PLATE
X-DIRECTION

NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION

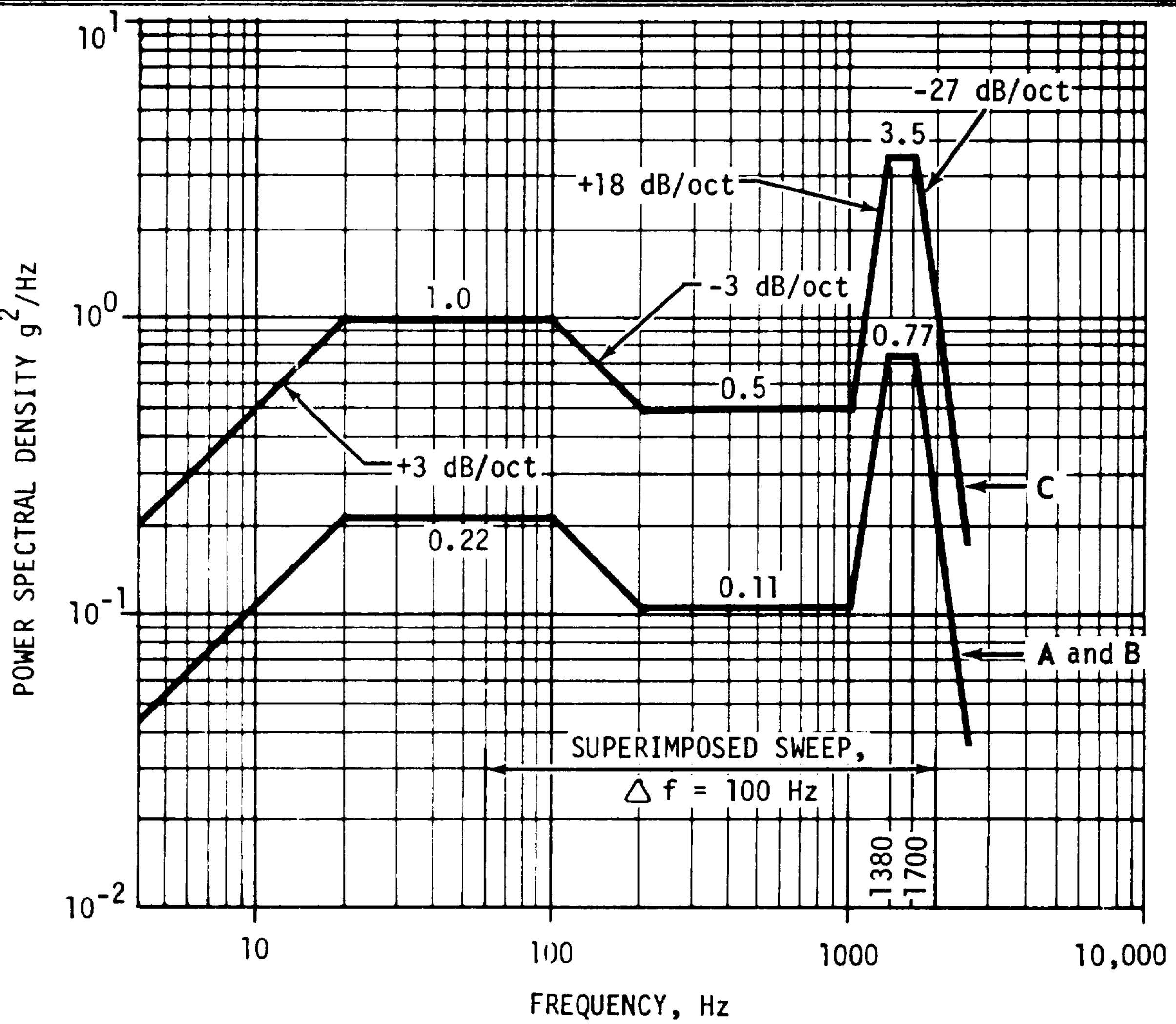


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	1.5	28.4
B	Lift-off Steady State Until Umbilical Disconnect	1.5	28.4
C	Lift-off Peak	3.5	57.9

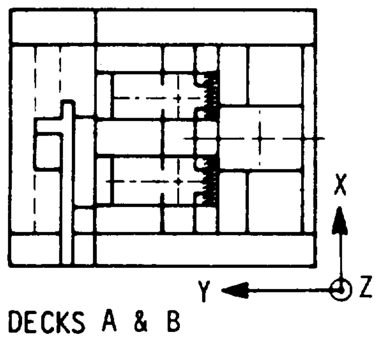


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.3.1 AND 1.3.3.1
GIRDER WEB PLATE
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

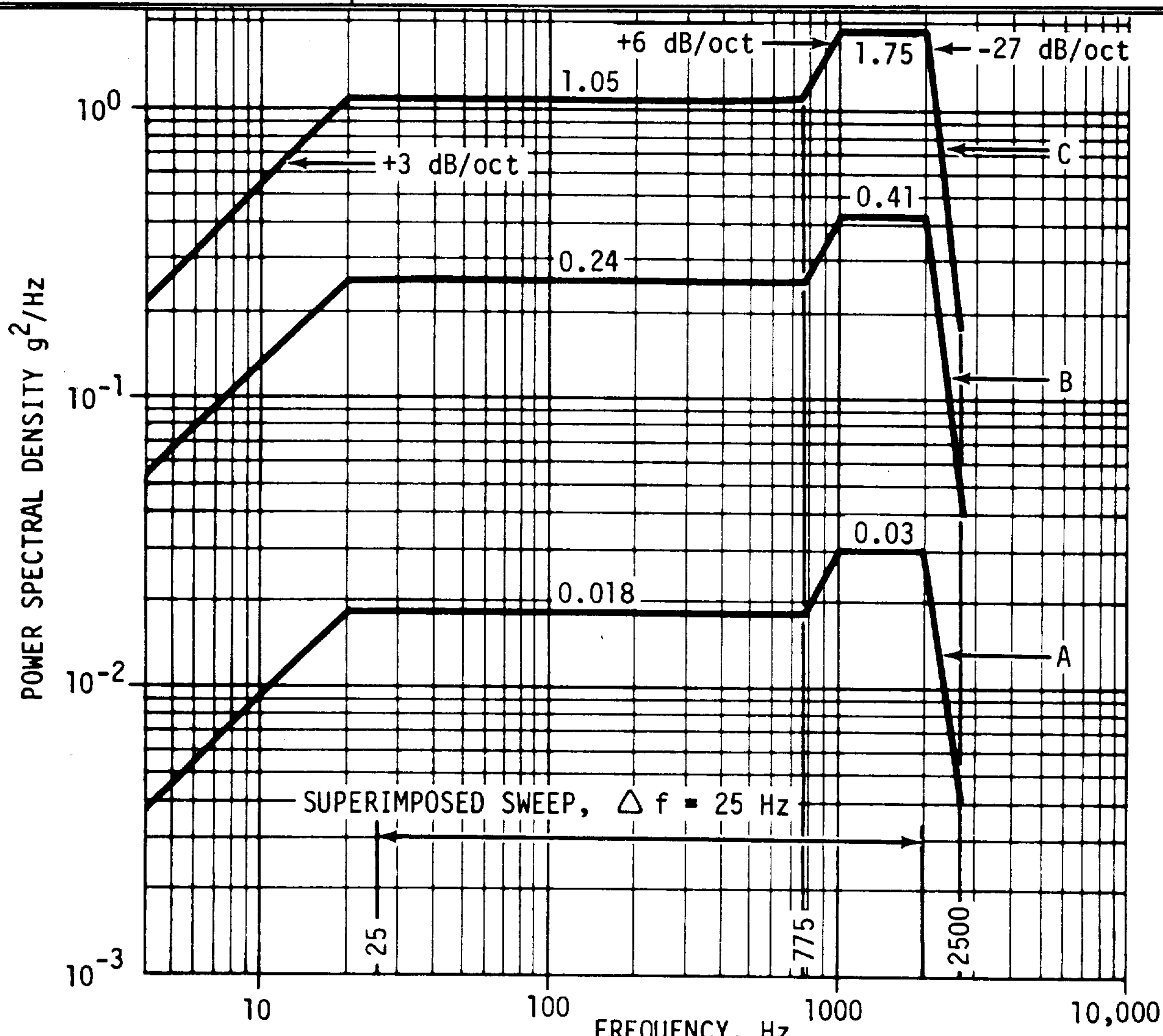


Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	1.5	28.4
B	Lift-off Steady State Until Umbilical Disconnect	1.5	28.4
C	Lift-off Peak	3.5	57.9

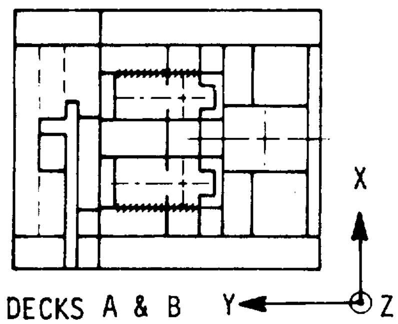


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.4 AND 1.3.4
GIRDER WEB STIFFENER
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

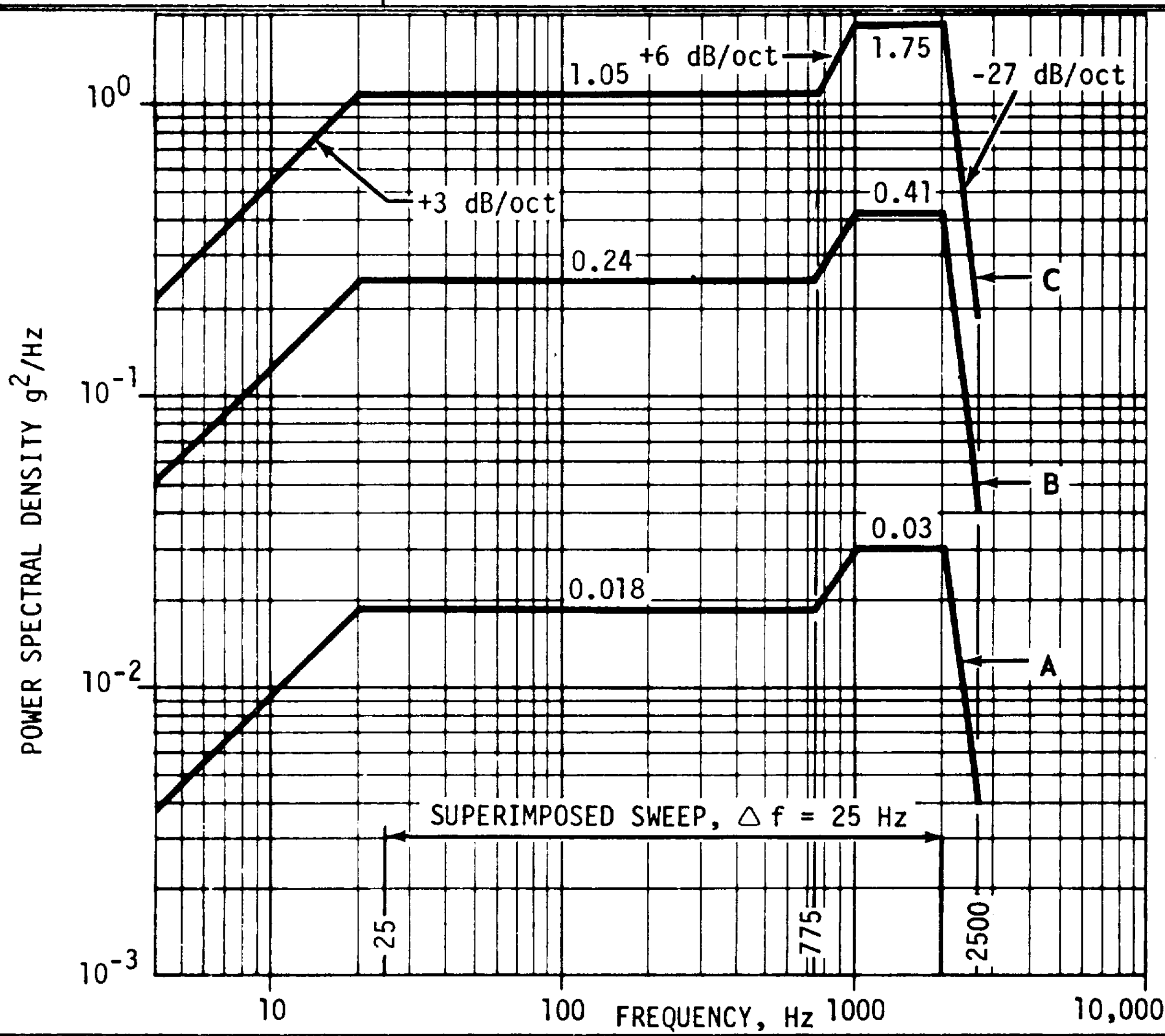


Sym.	Launch Stage	Sweep △PSD g²/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	7.5
B	Lift-off Steady State Until Umbilical Disconnect	1.4	28.1
C	Lift-off Peak	1.4	57.0

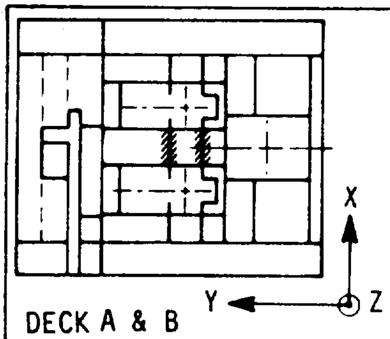


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.4 AND 1.3.4
GIRDER WEB STIFFENER
X-DIRECTION

NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION

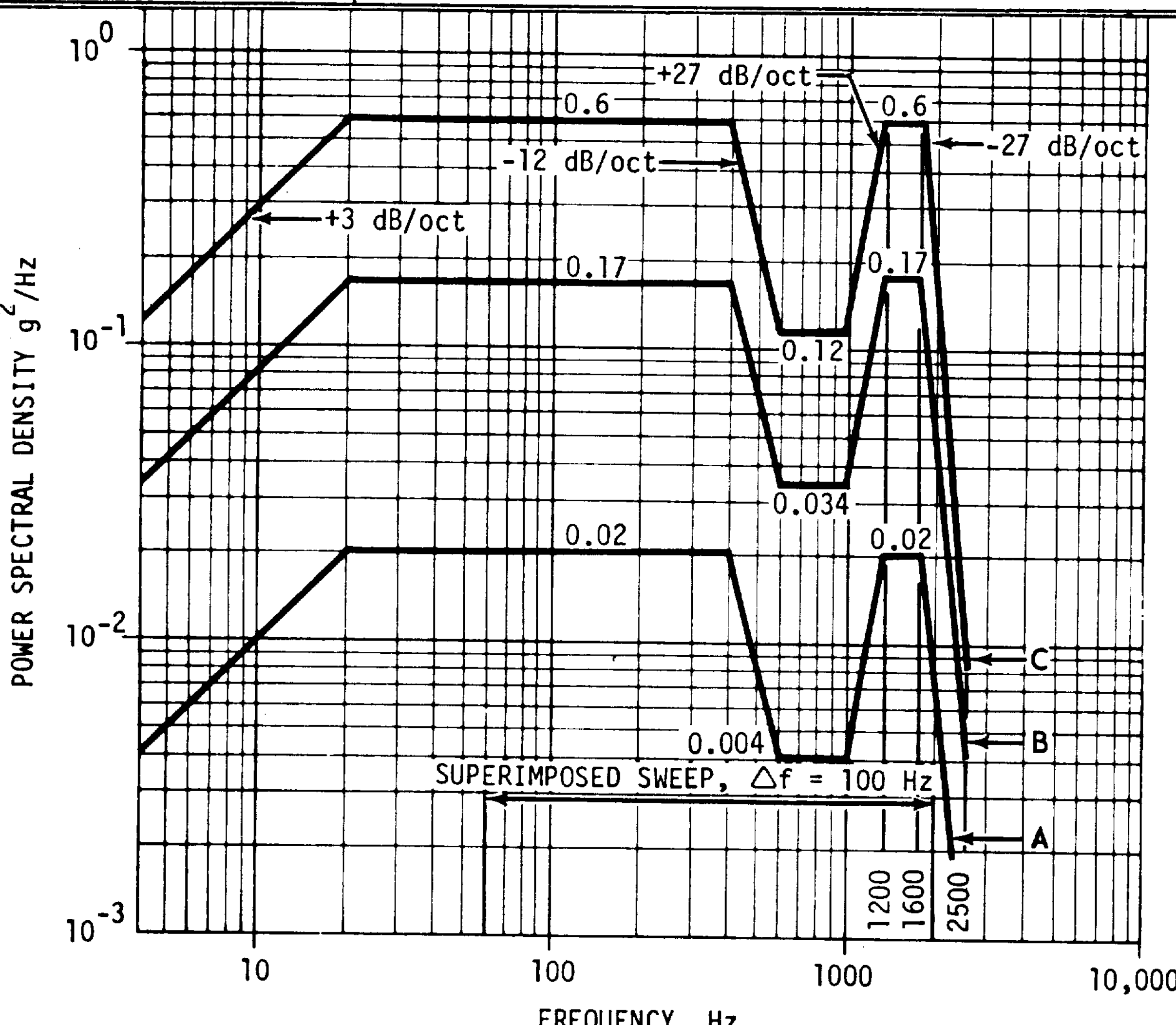


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	7.5
B	Lift-off Steady State Until Umbilical Disconnect	1.4	28.1
C	Lift-off Peak	1.4	57.0

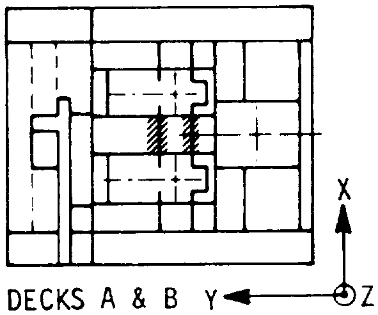


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.9 AND 1.3.9
GIRDER WEB STIFFENER
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

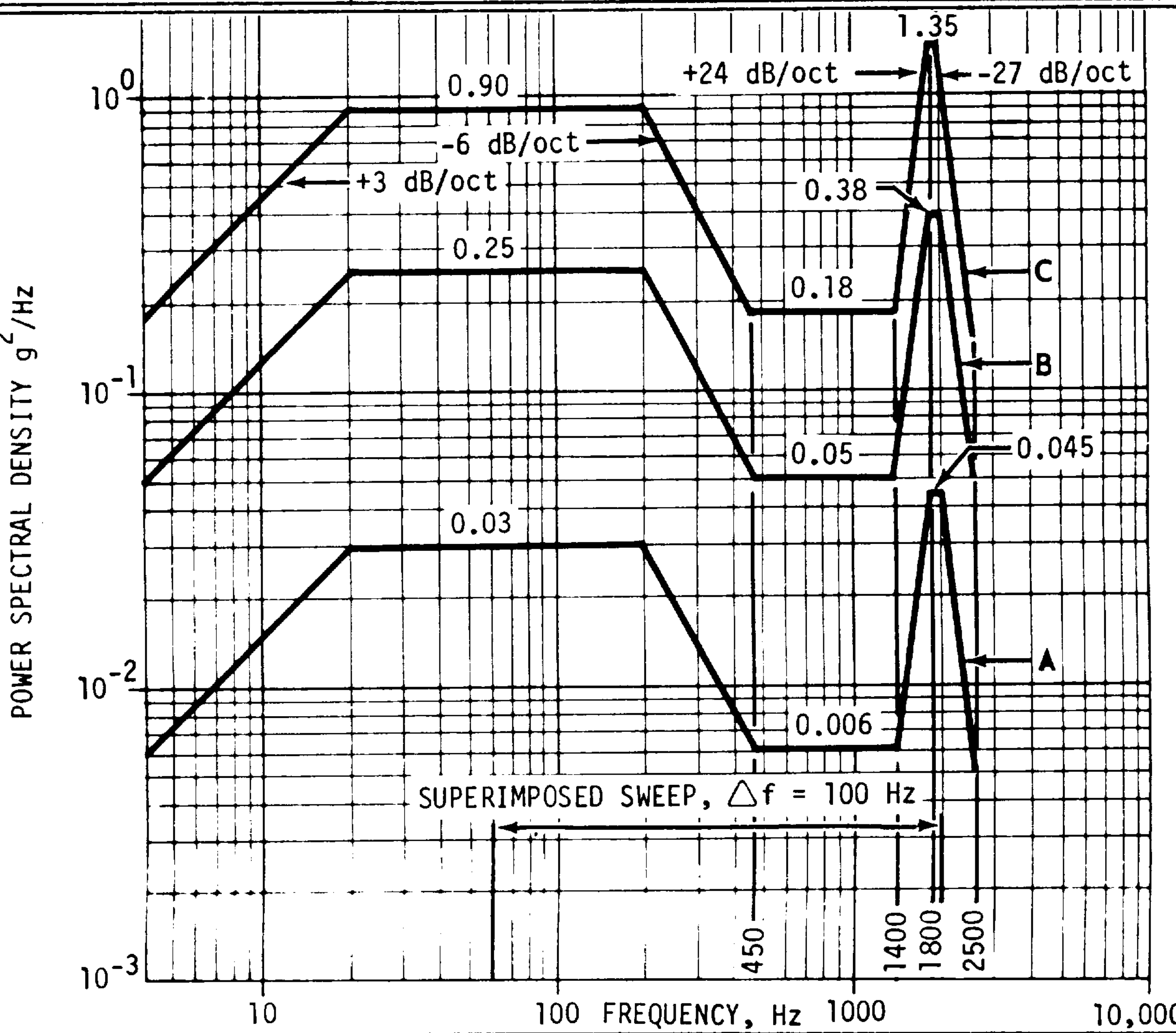


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.06	5.6
B	Lift-off Steady State Until Umbilical Disconnect	0.4	15.9
C	Lift-off Peak	0.8	28.9

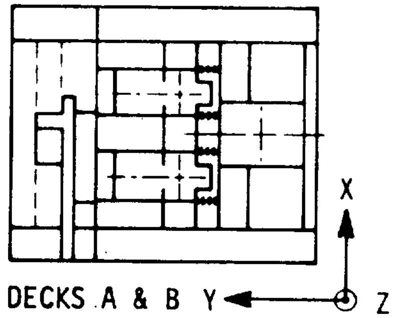


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.9.1 AND 1.3.9.1
GIRDER WEB PLATE
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

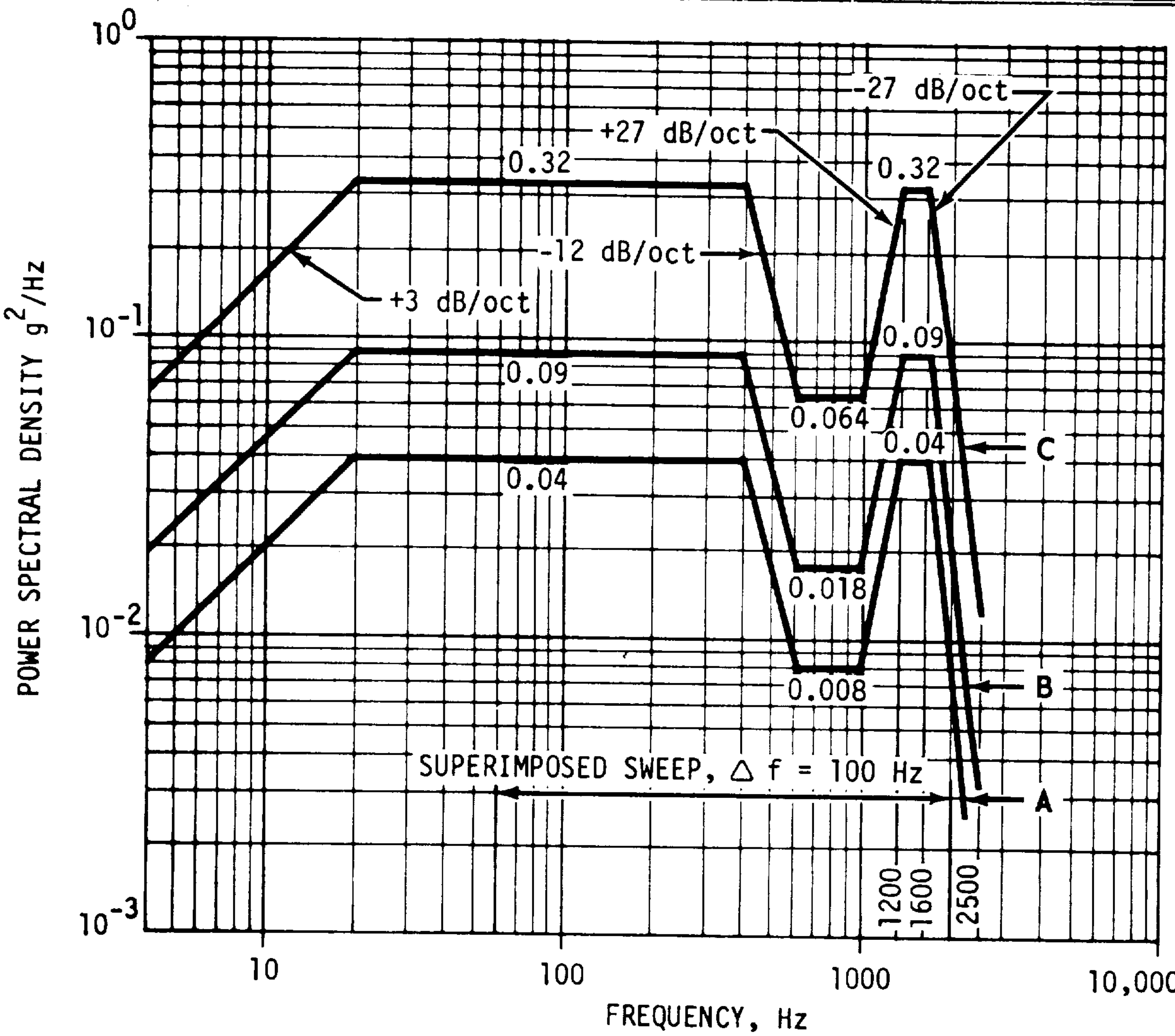


Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.09	7.1
B	Lift-off Steady State Until Umbilical Disconnect	0.6	20.1
C	Lift-off Peak	0.9	36.4

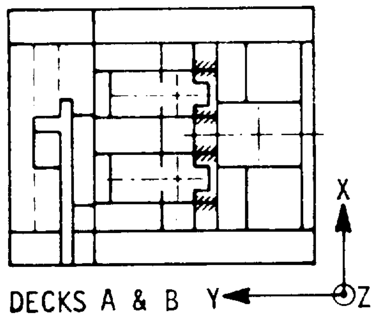


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.10 AND 1.3.10
GIRDER WEB STIFFENER
X-DIRECTION

NOTE: FOR Y AND Z DIRECTIONS SEE
GROUP SPECIFICATION

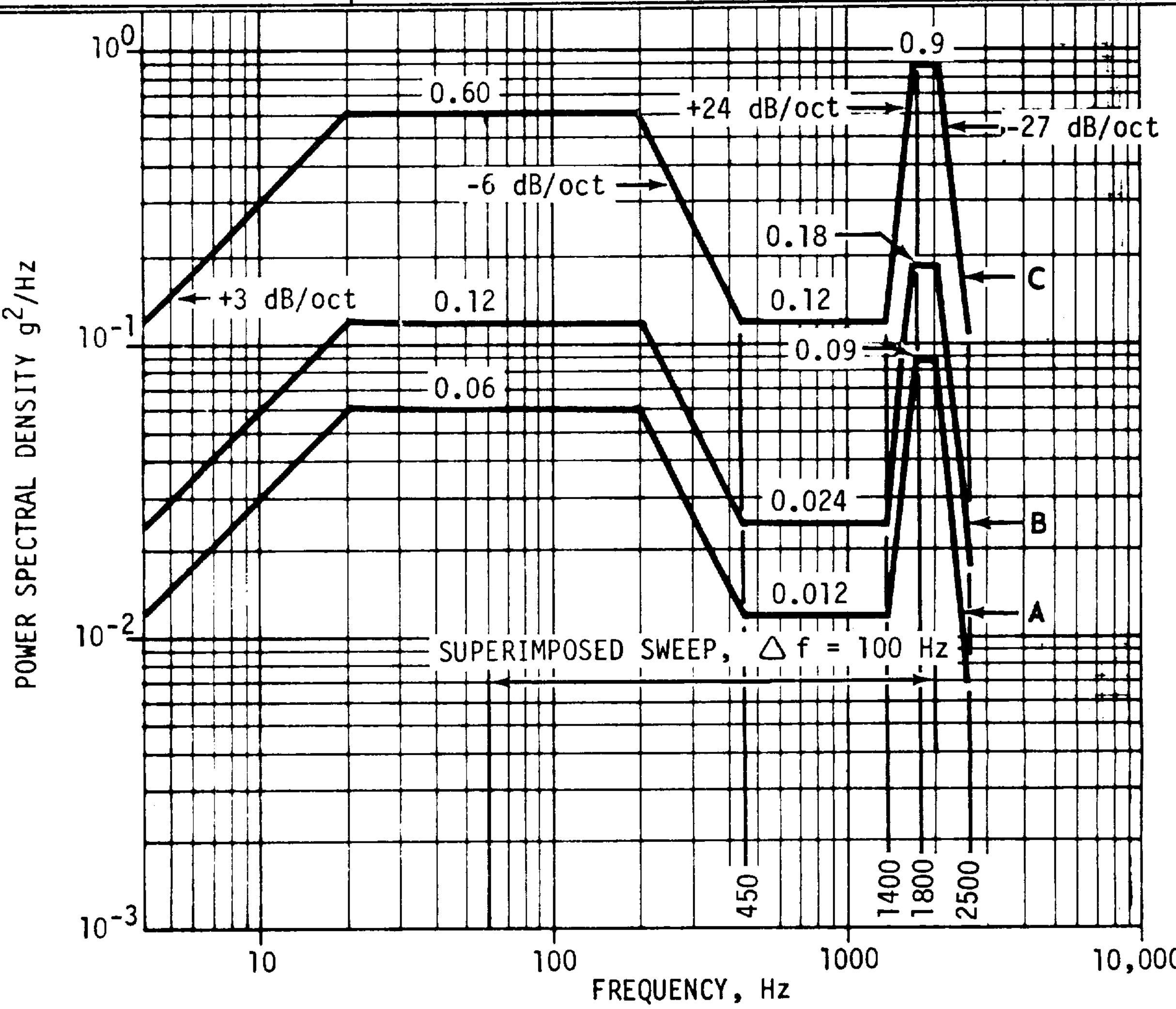


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	7.8
B	Lift-off Steady State Until Umbilical Disconnect	0.3	12.0
C	Lift-off Peak	0.4	21.0

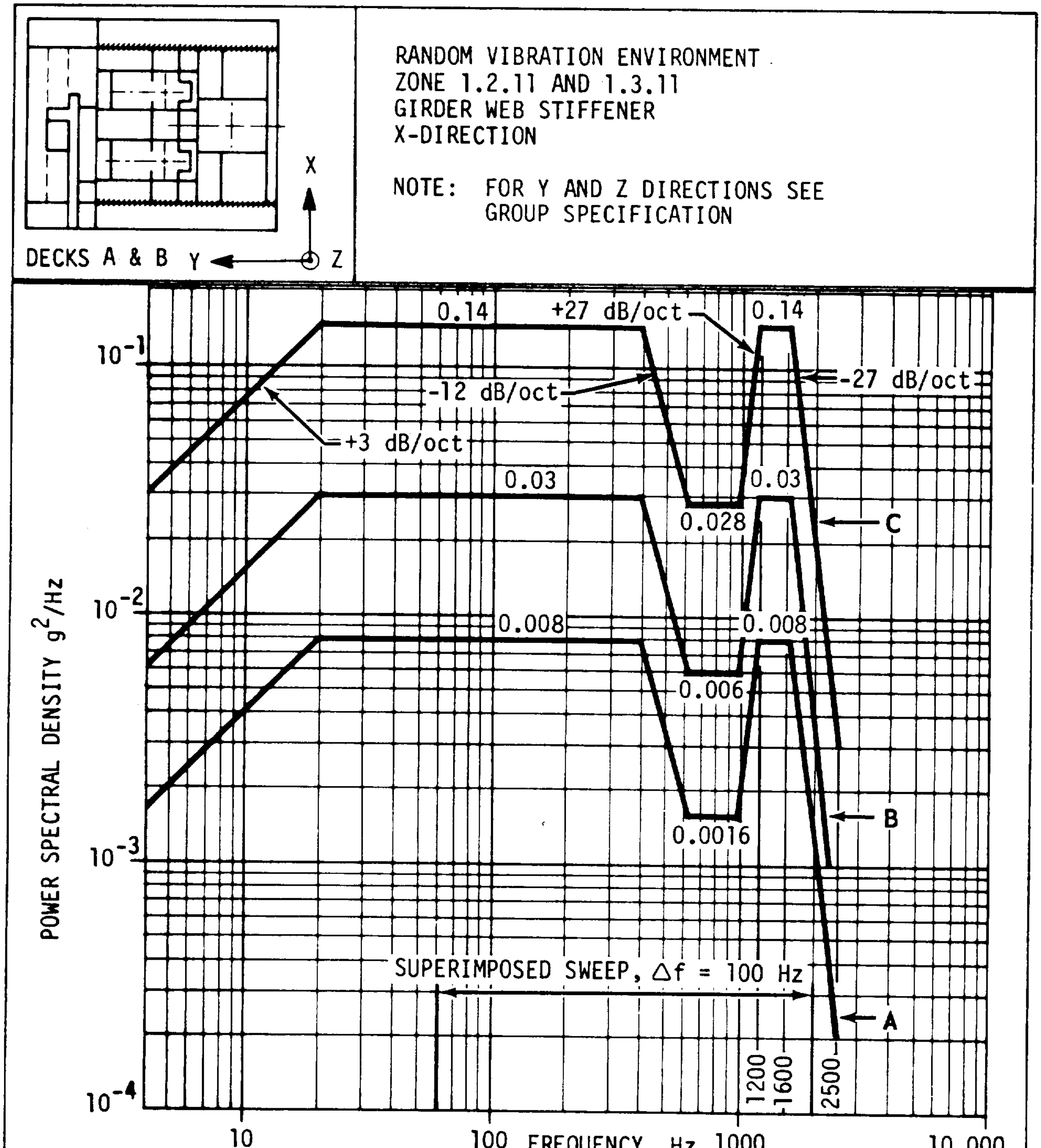


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.10.1 AND 1.3.10.1
GIRDER WEB PLATE
X-DIRECTION

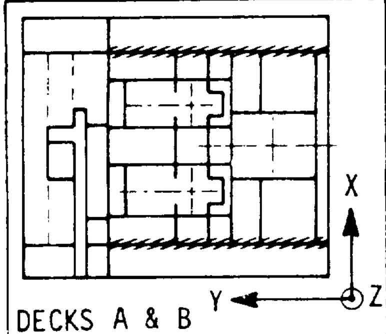
NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION



Sym	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.15	9.9
B	Lift-off Steady State Until Umbilical Disconnect	0.3	14.0
C	Lift-off Peak	0.6	29.7

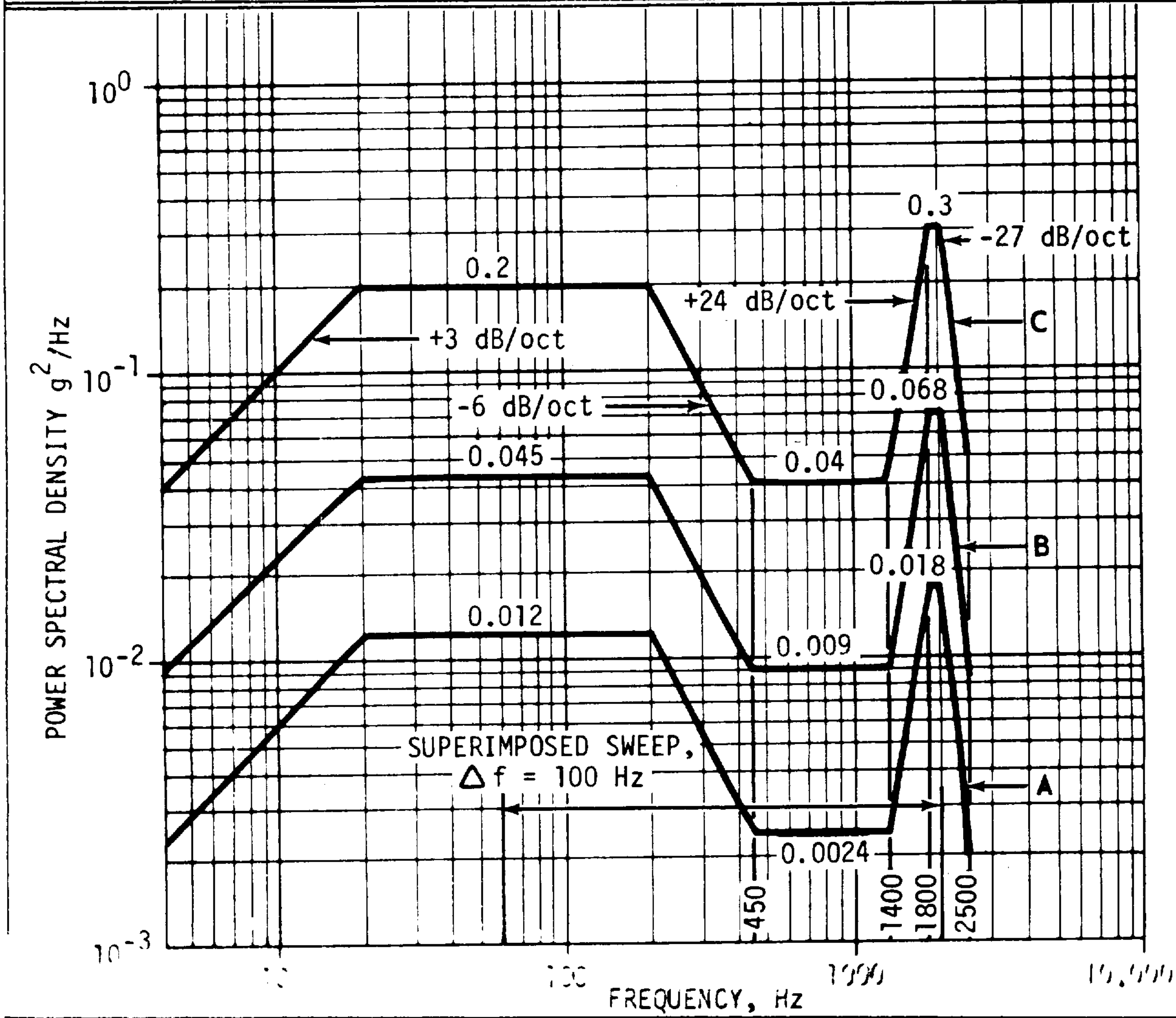


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	3.5
B	Lift-off Steady State Until Umbilical Disconnect	0.08	6.8
C	Lift-off Peak	0.3	14.4

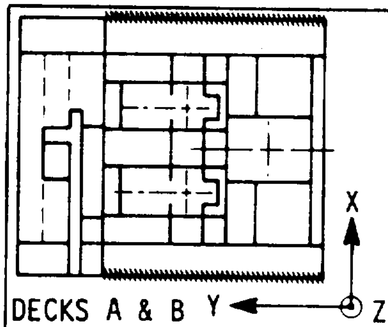


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.11.1 AND 1.3.11.1
GIRDER WEB PLATE
X-DIRECTION

NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION

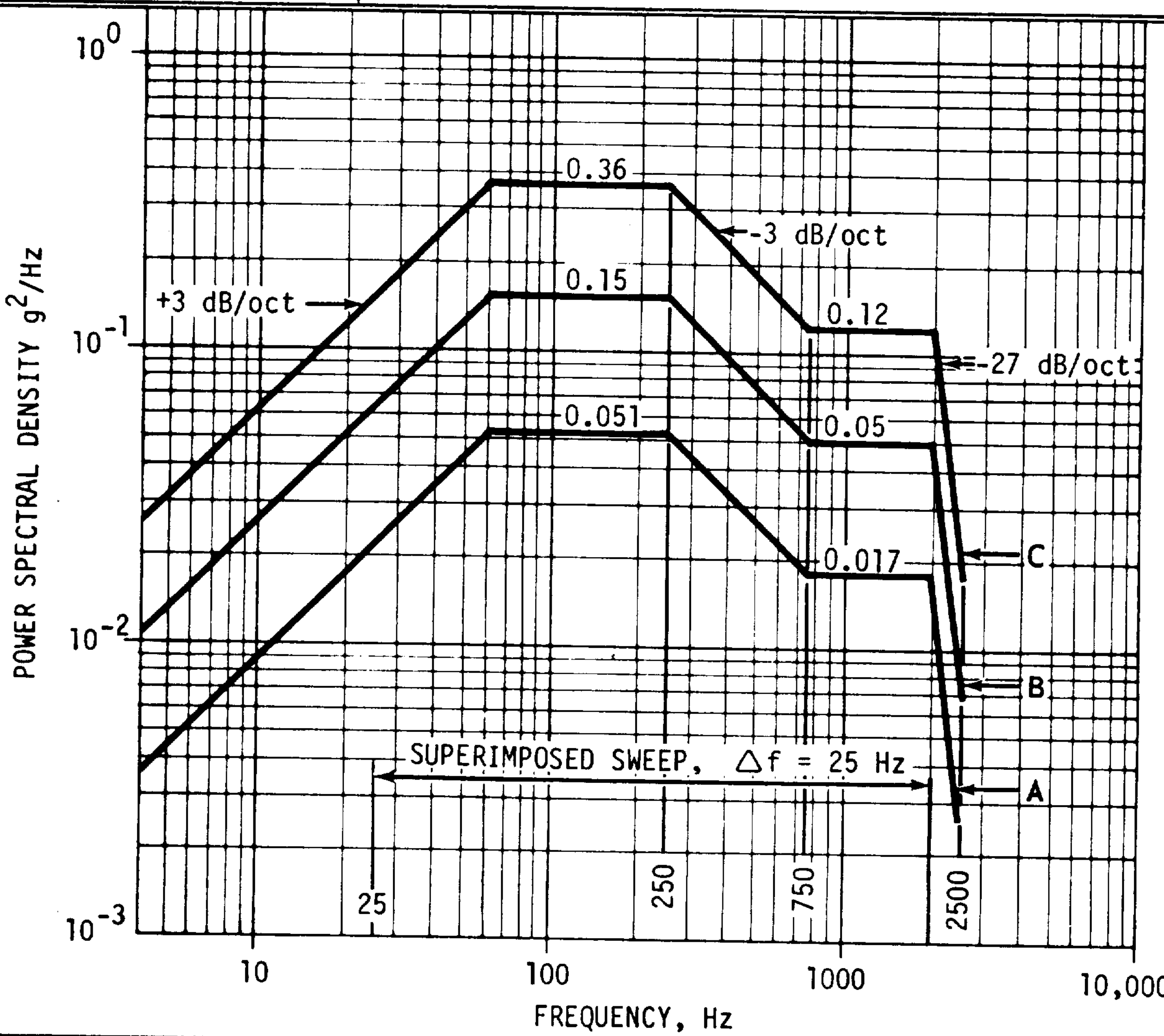


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.03	4.4
B	Lift-off Steady State Until Umbilical Disconnect	0.12	8.6
C	Lift-off Peak	0.3	17.4

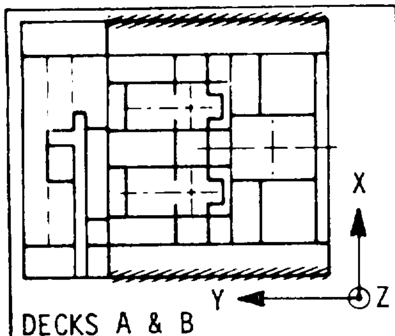


RANDOM VIBRATION ENVIRONMENT
ZONES 1.2.12 AND 1.3.12
GIRDER WEB STIFFENER
X-DIRECTION

NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION

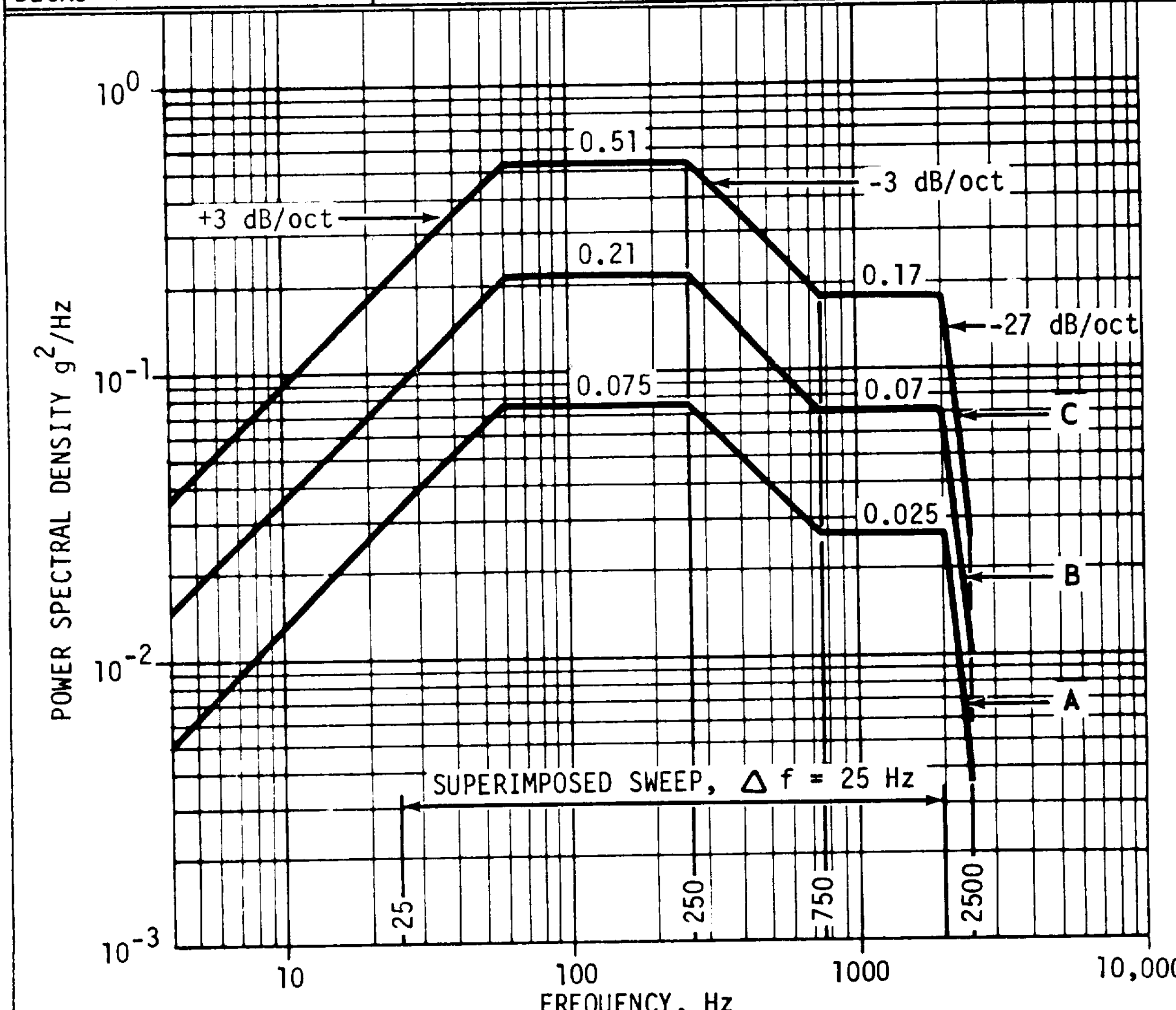


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.2	7.5
B	Lift-off Steady State Until Umbilical Disconnect	0.6	12.8
C	Lift-off Peak	0.7	19.2

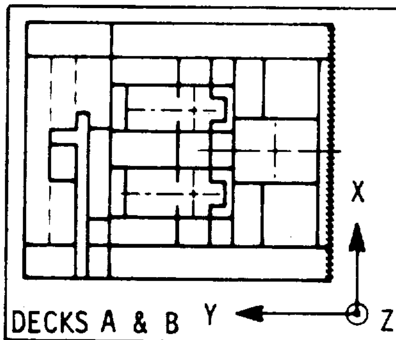


RANDOM VIBRATION ENVIRONMENT
ZONES 1.2.12.1 AND 1.3.12.1
GIRDER WEB PLATE
X-DIRECTION

NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION

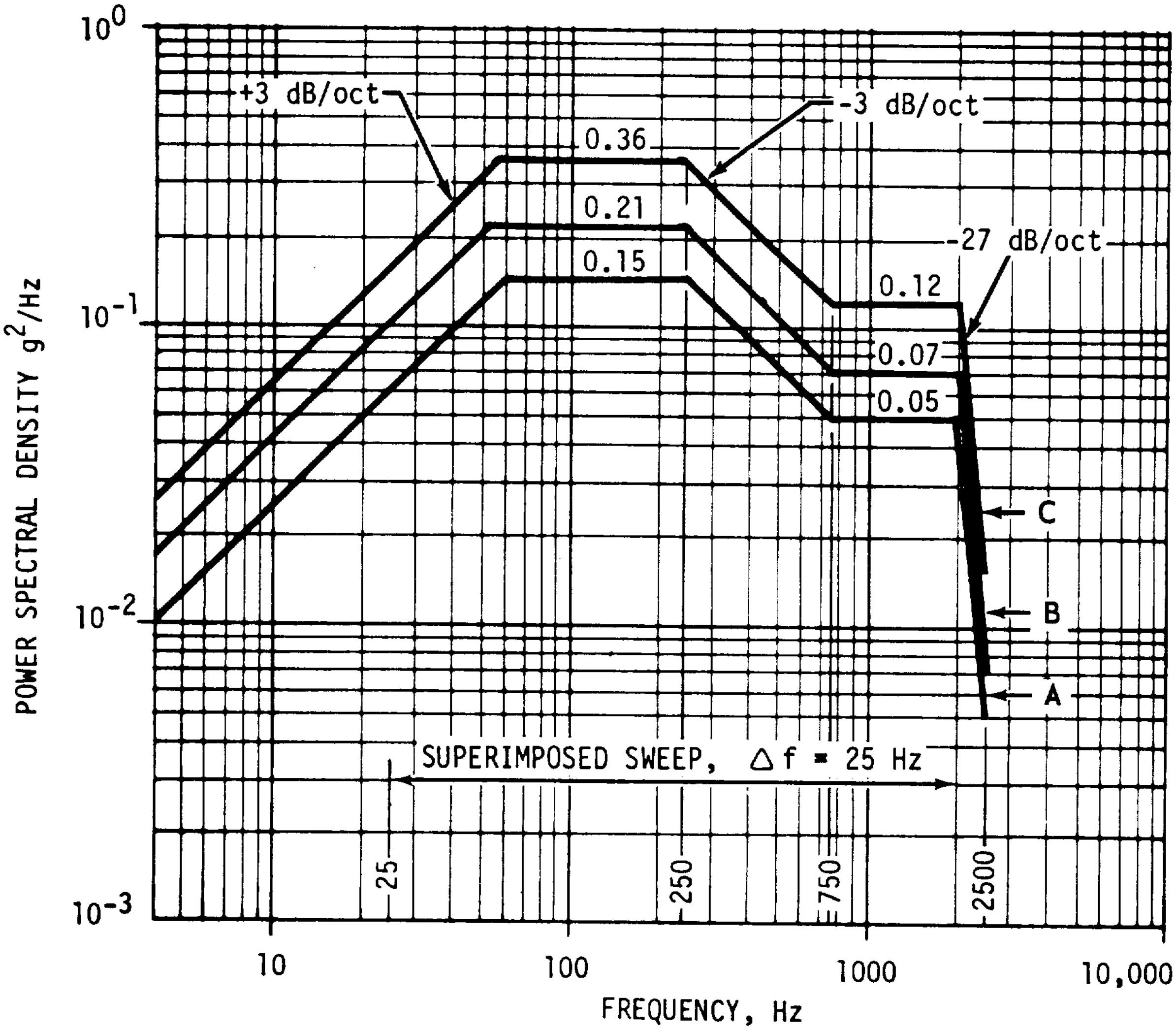


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.3	9.0
B	Lift-off Steady State Until Umbilical Disconnect	0.9	15.1
C	Lift-off Peak	1.0	22.9

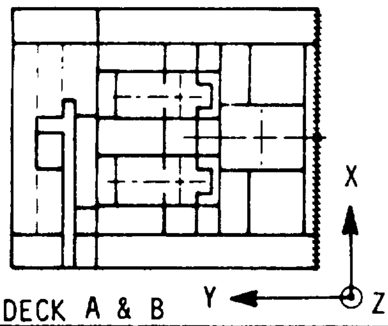


RANDOM VIBRATION ENVIRONMENT
ZONES 1.2.13 AND 1.3.13
GIRDER WEB STIFFENER
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION



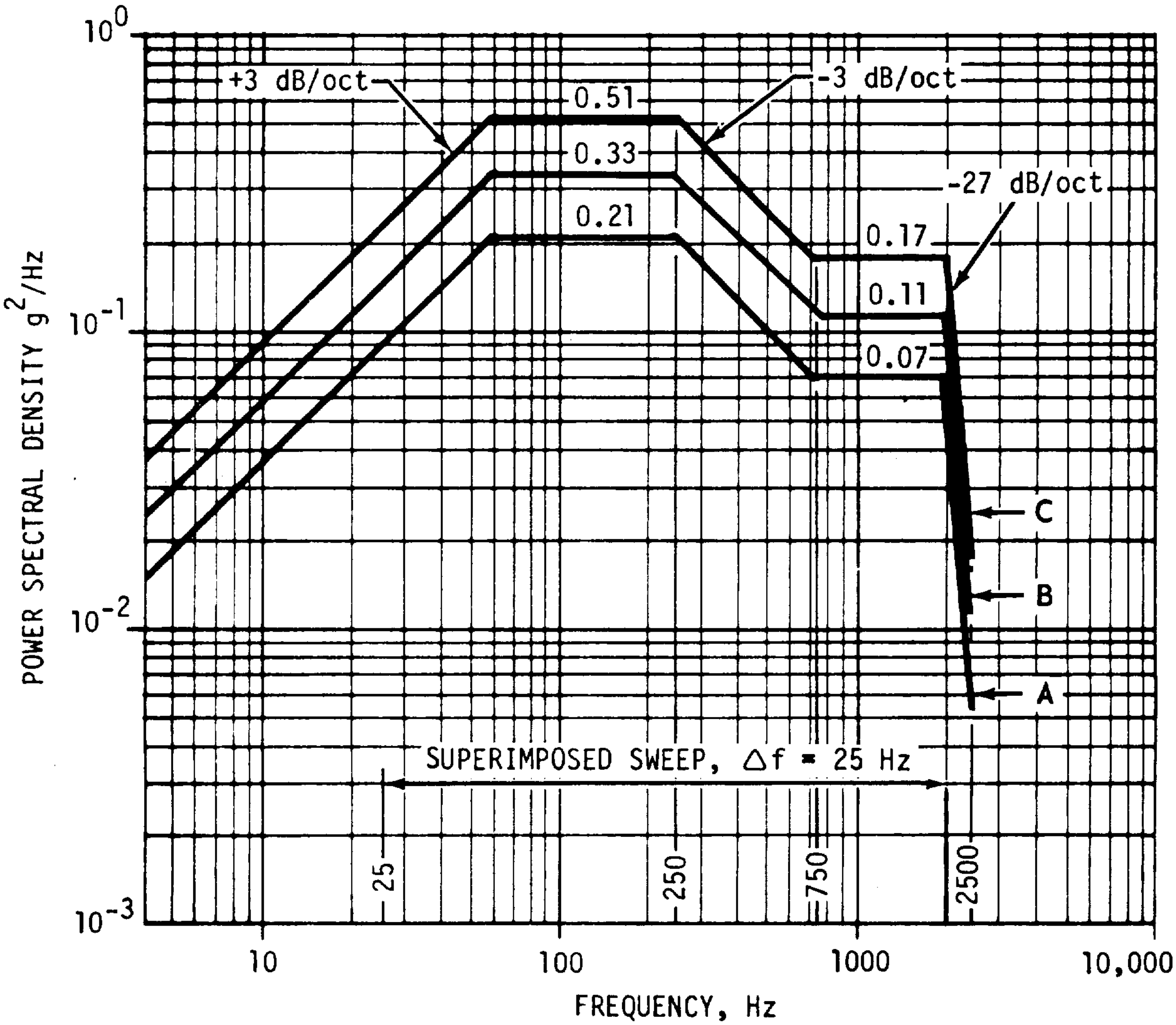
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.6	12.7
B	Lift-off Steady State Until Umbilical Disconnect	0.7	14.9
C	Lift-off Peak	0.7	19.2



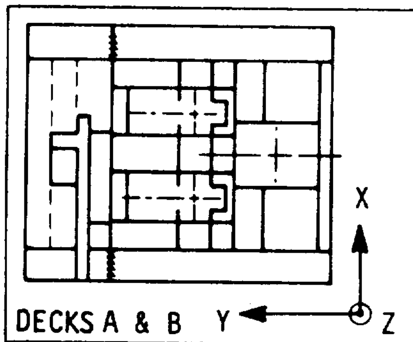
DECK A & B

RANDOM VIBRATION ENVIRONMENT
ZONES 1.2.13.1 AND 1.3.13.1
GIRDER WEB PLATE
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

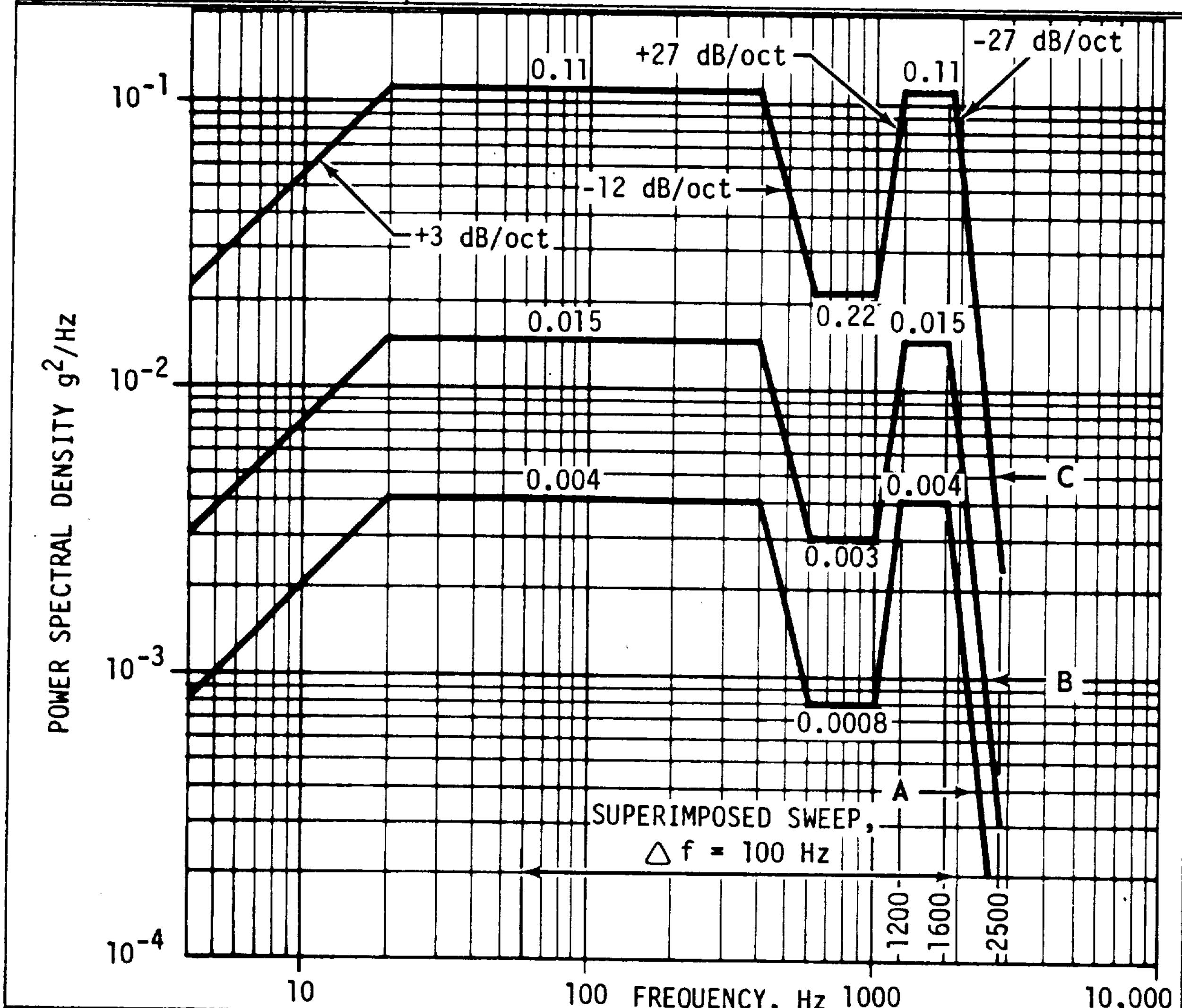


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.85	15.0
B	Lift-off Steady State Until Umbilical Disconnect	1.0	18.6
C	Lift-off Peak	1.0	22.9

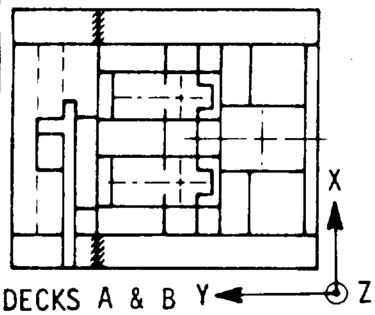


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.14 AND 1.3.14
GIRDER WEB STIFFENER
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

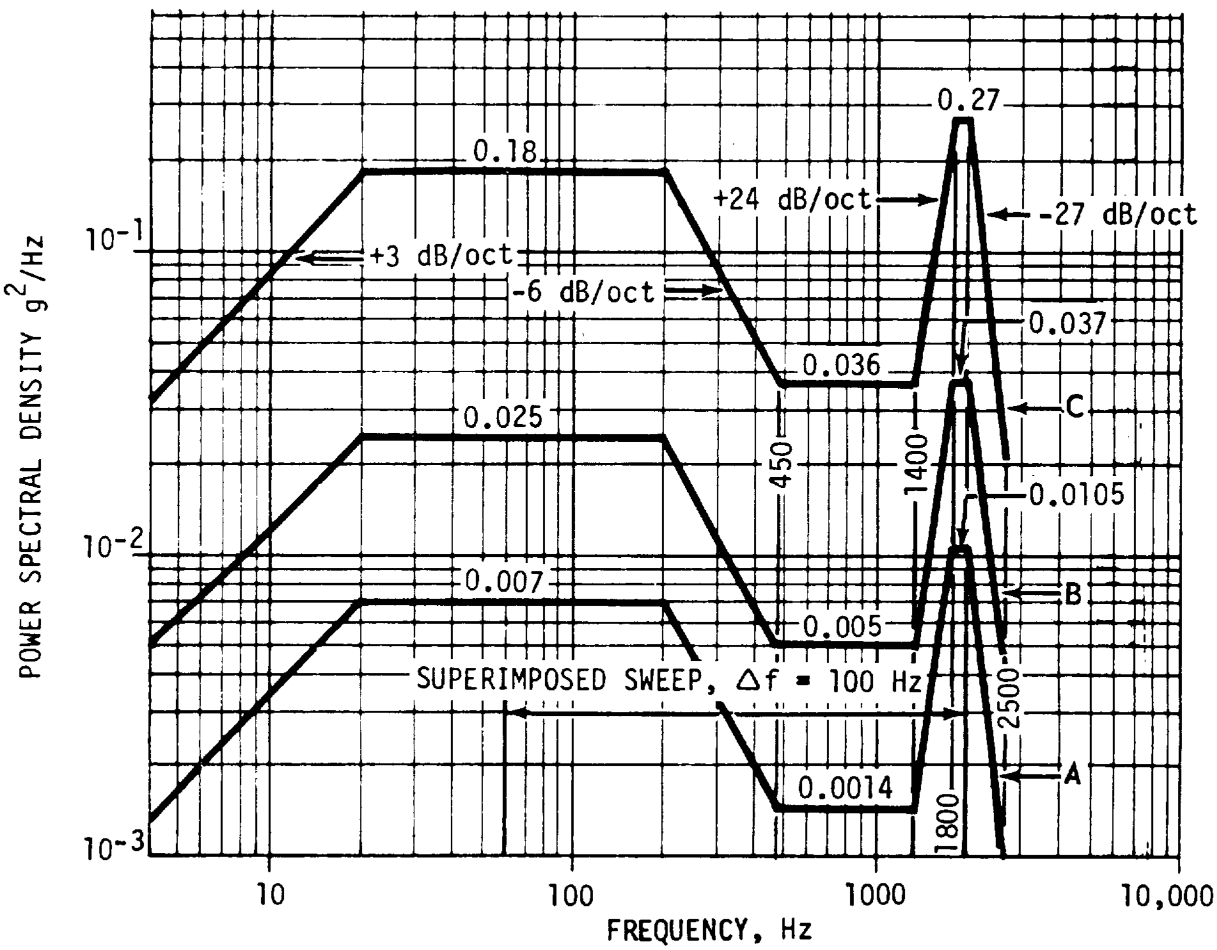


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	2.5
B	Lift-off Steady State Until Umbilical Disconnect	0.03	4.7
C	Lift-off Peak	0.15	12.4



RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.14.1 AND 1.3.14.1
GIRDER WEB PLATE
Y-DIRECTION

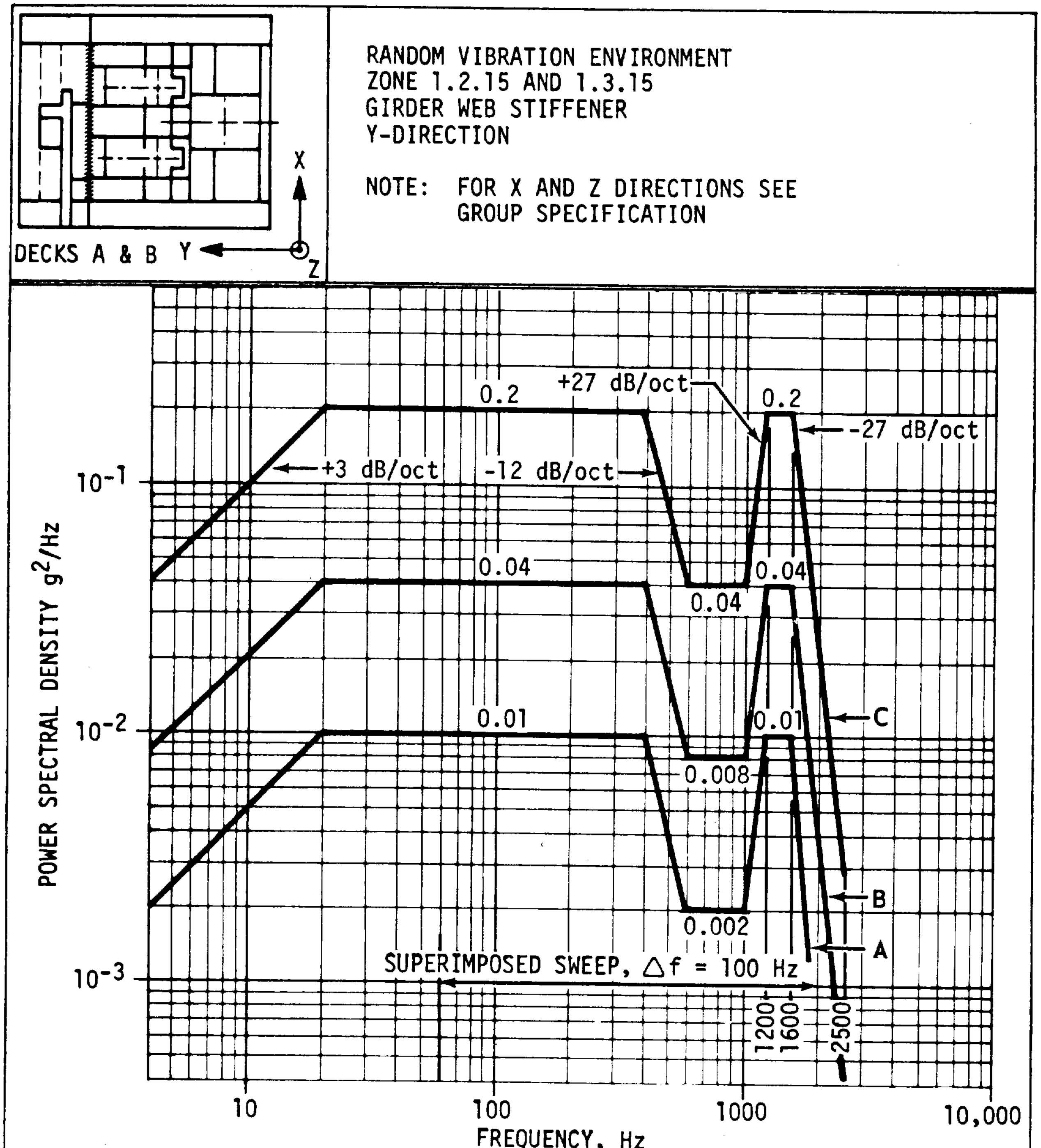
NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION



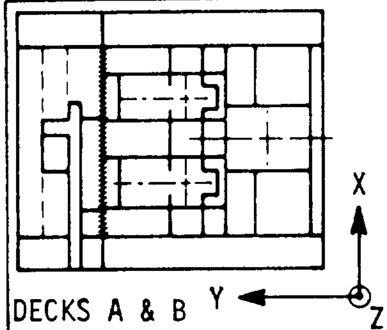
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0,02	3.4
B	Lift-off Steady State Until Umbilical Disconnect	0.07	6.4
C	Lift-off Peak	0.3	16.6

RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.15 AND 1.3.15
GIRDER WEB STIFFENER
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

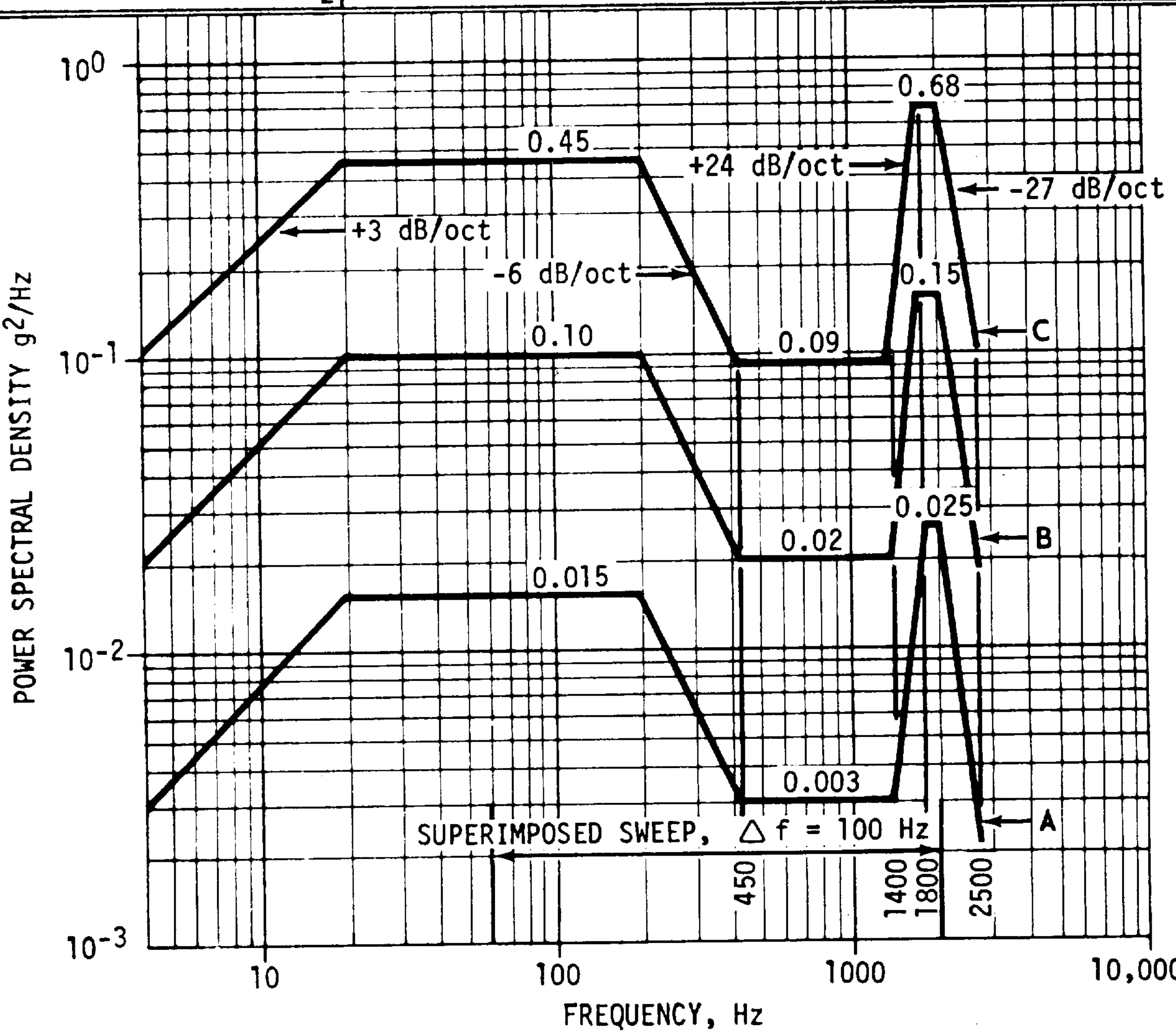


Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	3.8
B	Lift-off Steady State Until Umbilical Disconnect	0.04	7.6
C	Lift-off Peak	0.2	16.8

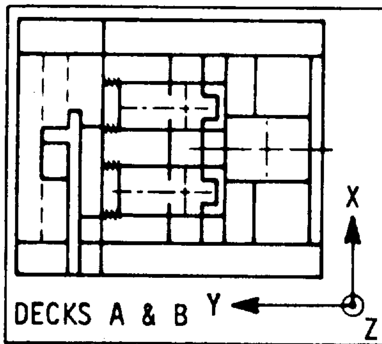


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.15.1 AND 1.3.15.1
GIRDER WEB PLATE
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

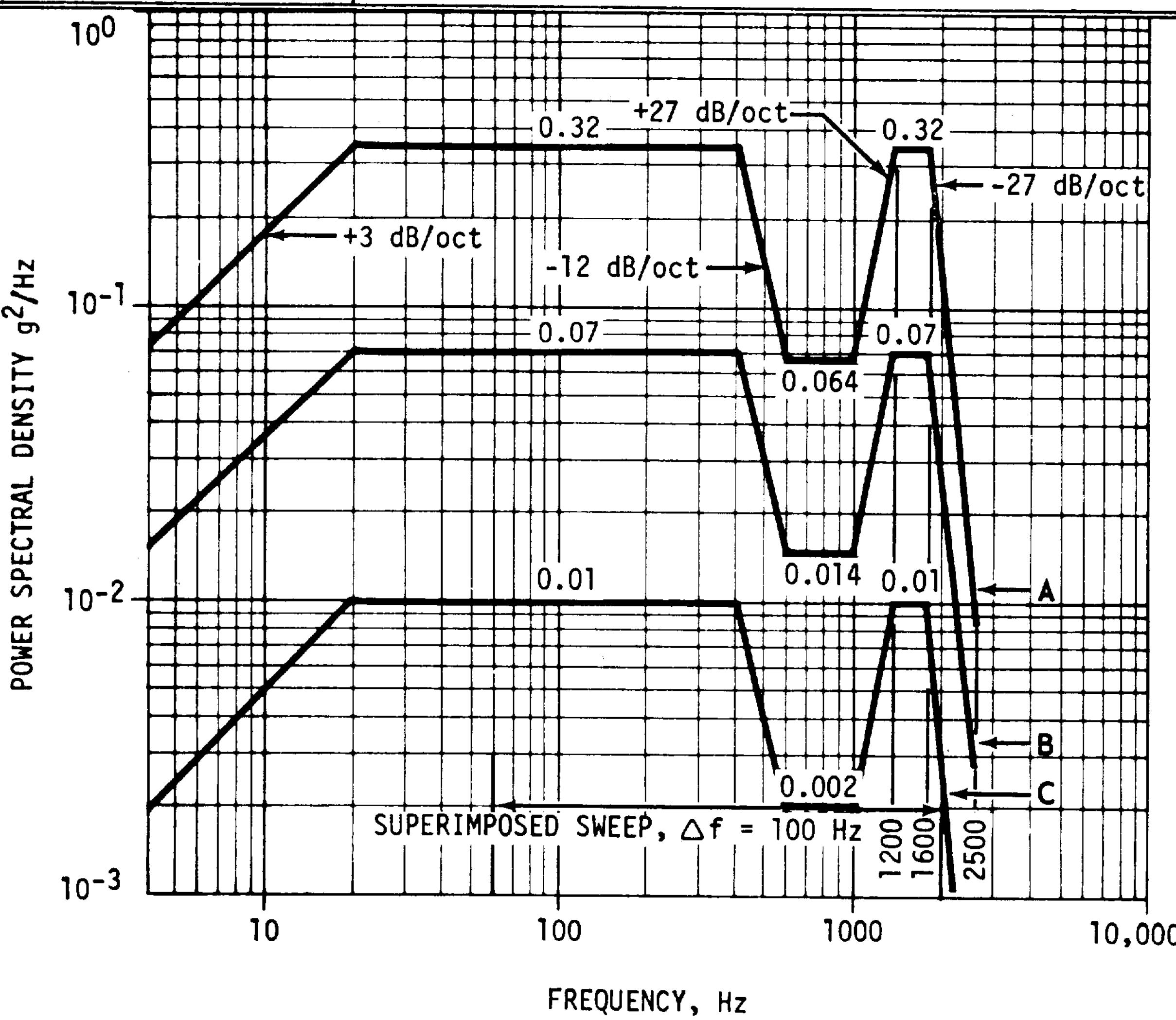


Sym.	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.015	5.0
B	Lift-off Steady State Until Umbilical Disconnect	0.3	12.9
C	Lift-off Peak	0.5	25.8

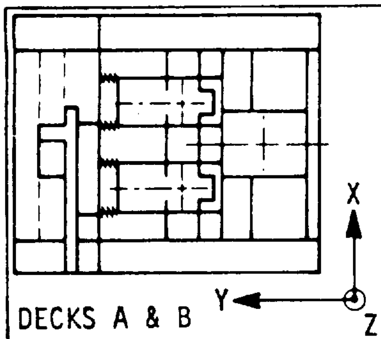


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.16 AND 1.3.16
GIRDER WEB STIFFENER
X-DIRECTION

NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION

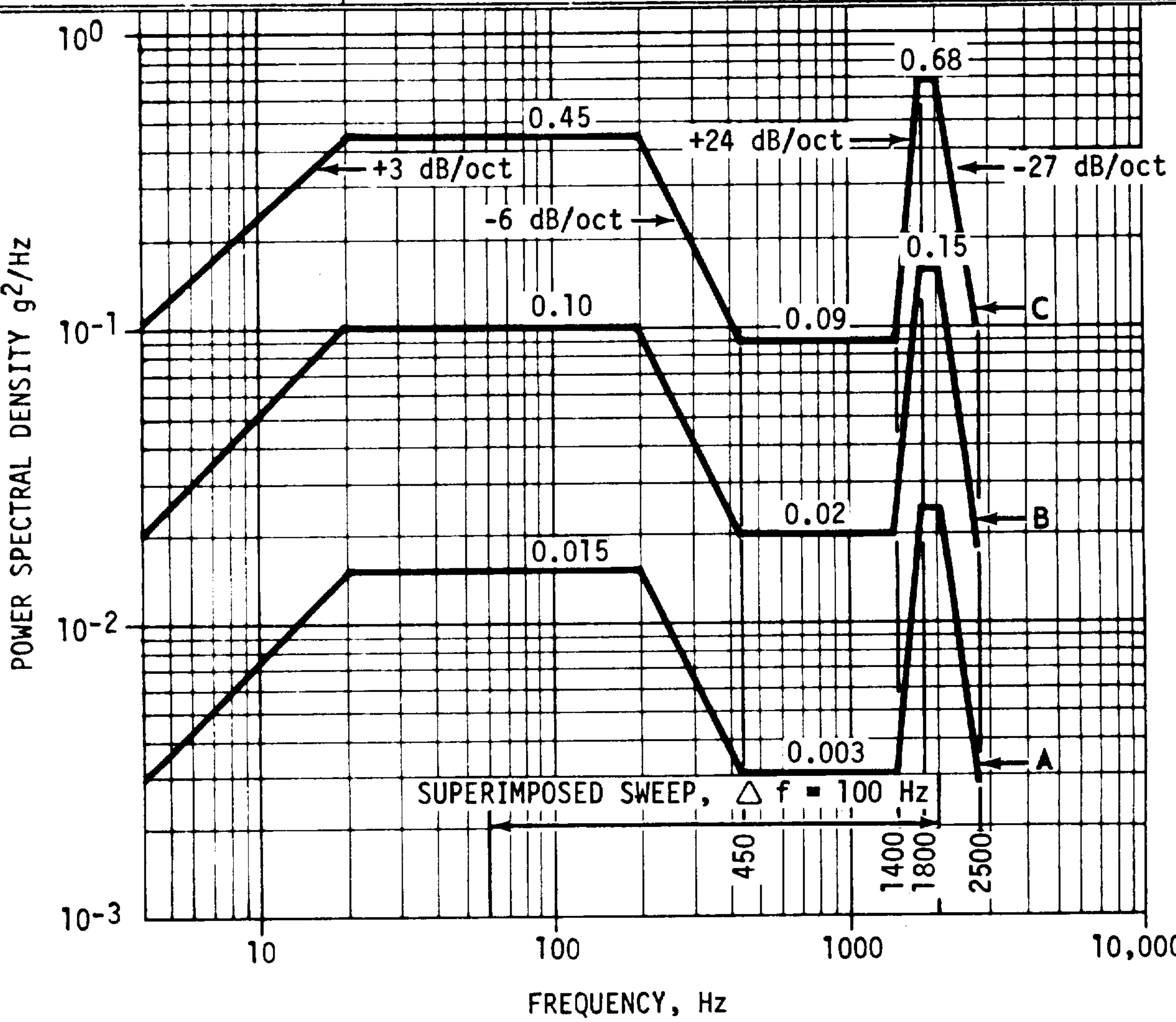


Sym.	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	3.8
B	Lift-off Steady State Until Umbilical Disconnect	0.2	10.4
C	Lift-off Peak	0.4	21.0

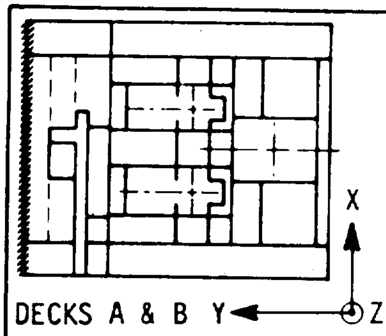


RANDOM VIBRATION ENVIRONMENT
ZONE 1.2.16.1 AND 1.3.16.1
GIRDER WEB PLATE
X-DIRECTION

NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION

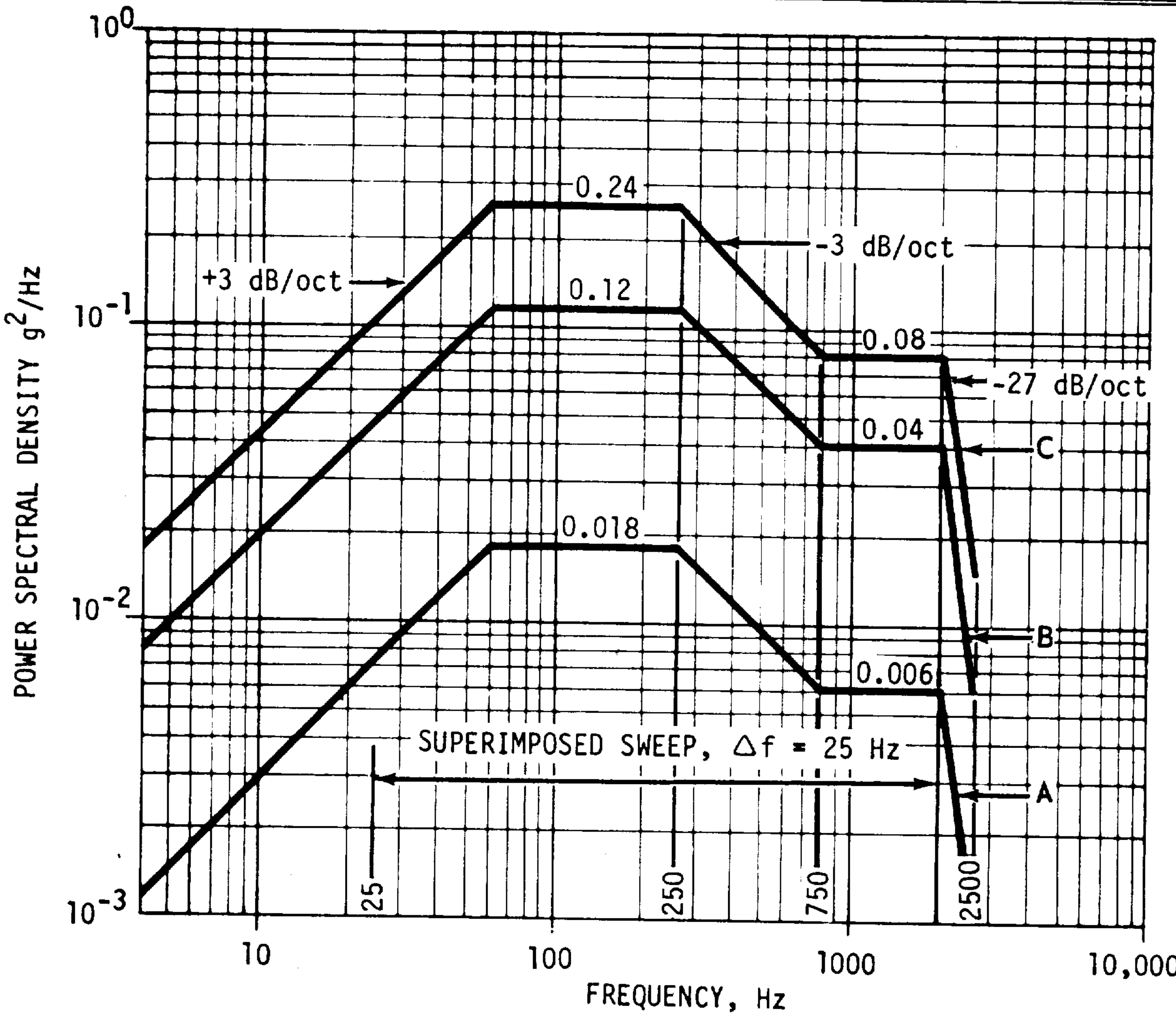


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.04	5.0
B	Lift-off Steady State Until Umbilical Disconnect	0.3	12.9
C	Lift-off Peak	0.5	25.8

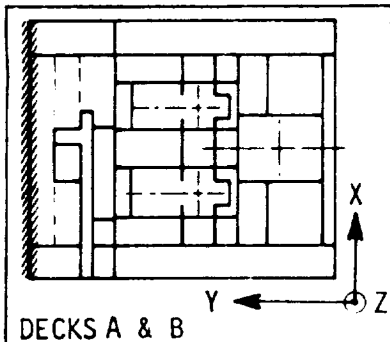


RANDOM VIBRATION ENVIRONMENT
ZONES 2.2.3 AND 2.3.3
GIRDER WEB STIFFENER
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

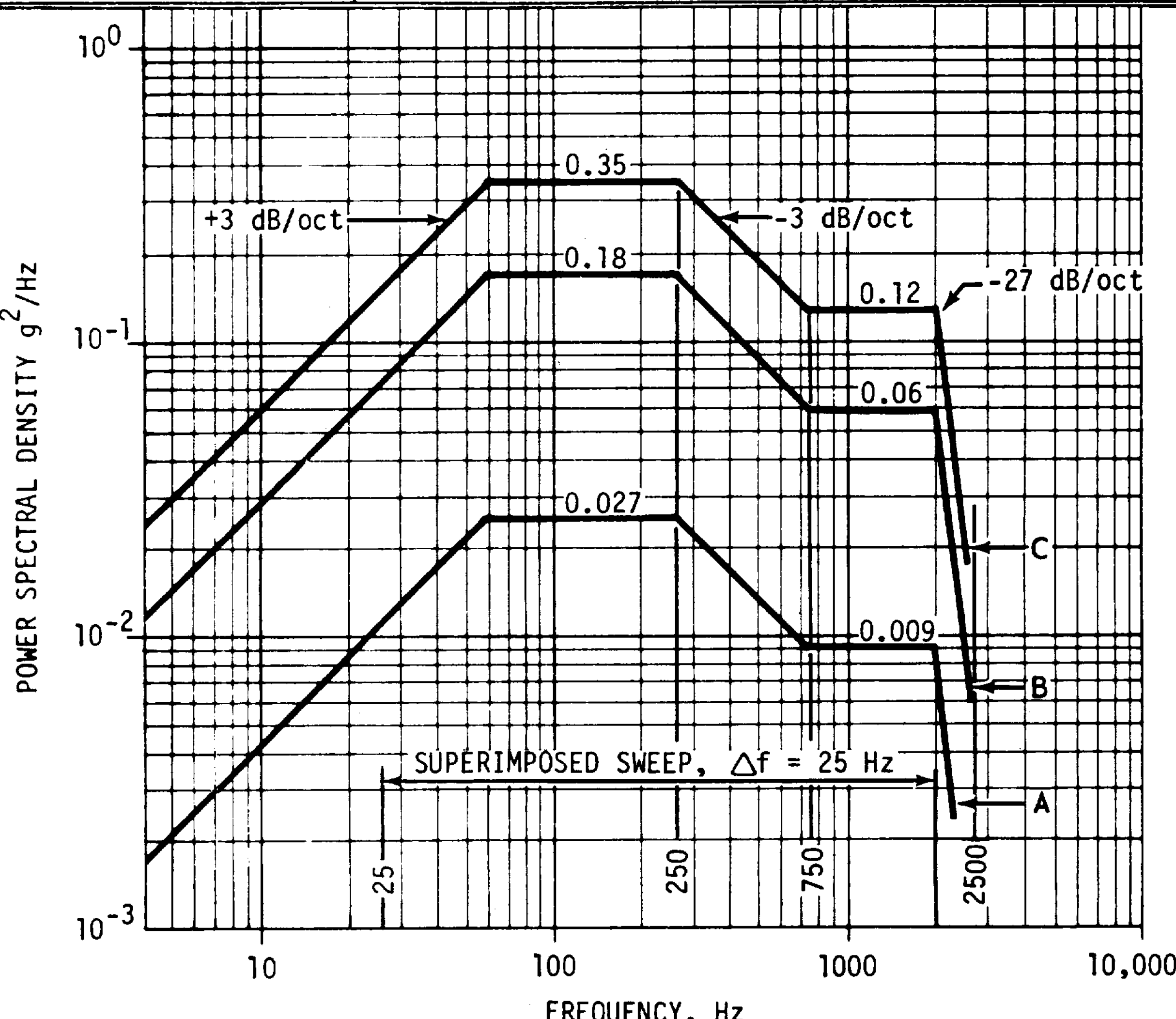


Sym.	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.25	4.9
B	Lift-off Steady State Until Umbilical Disconnect	0.35	11.2
C	Lift-off Peak	0.5	15.7

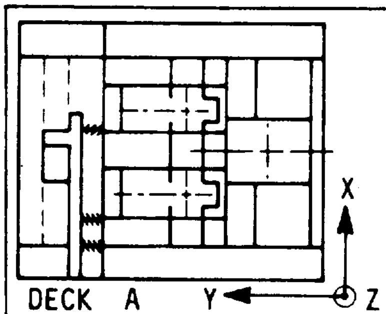


RANDOM VIBRATION ENVIRONMENT
ZONES 2.2.3.1 AND 2.3.3.1
GIRDER WEB PLATE
Y-DIRECTION

NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

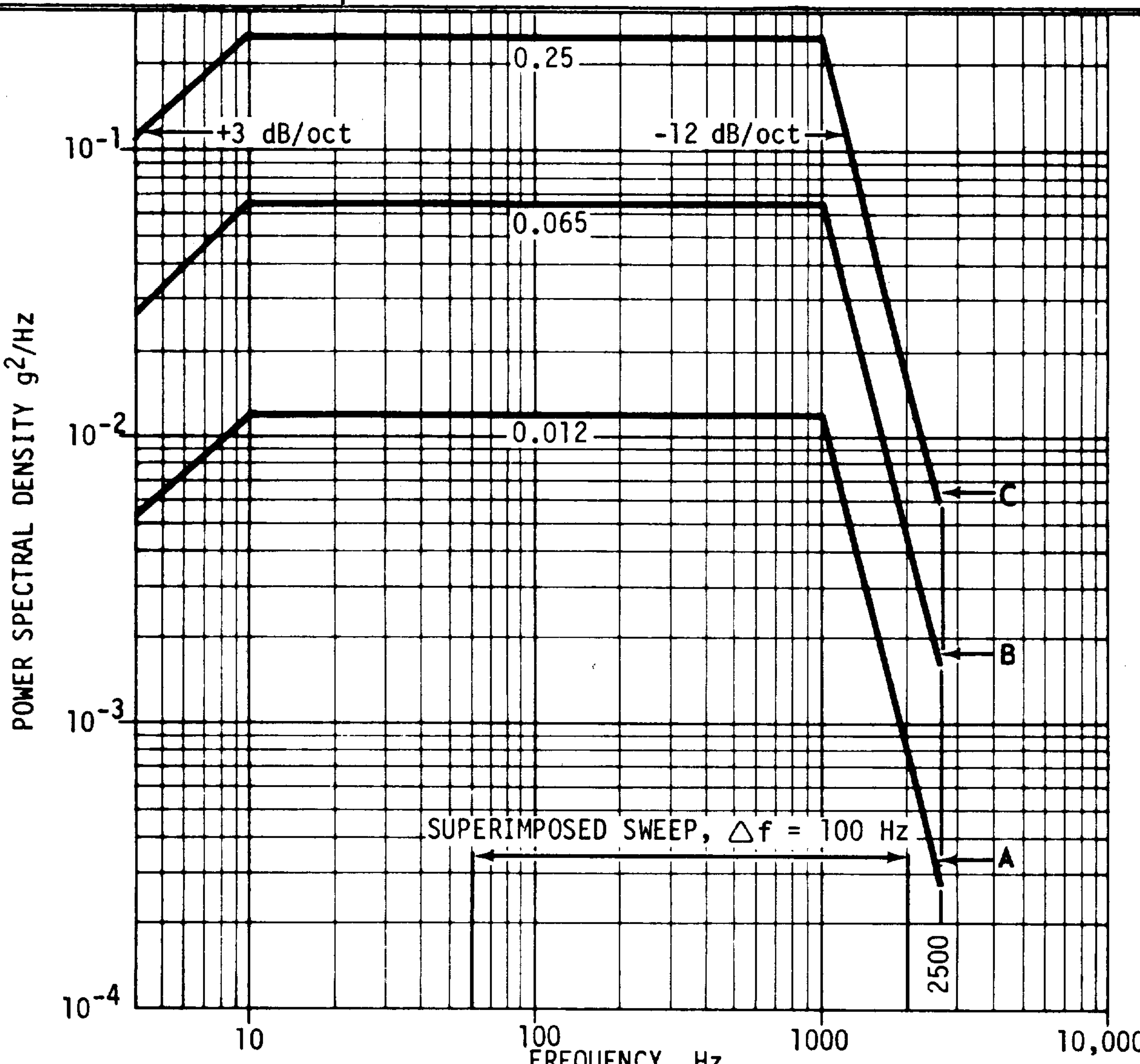


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	5.4
B	Lift-off Steady State Until Umbilical Disconnect	0.5	13.7
C	Lift-off Peak	0.7	19.2

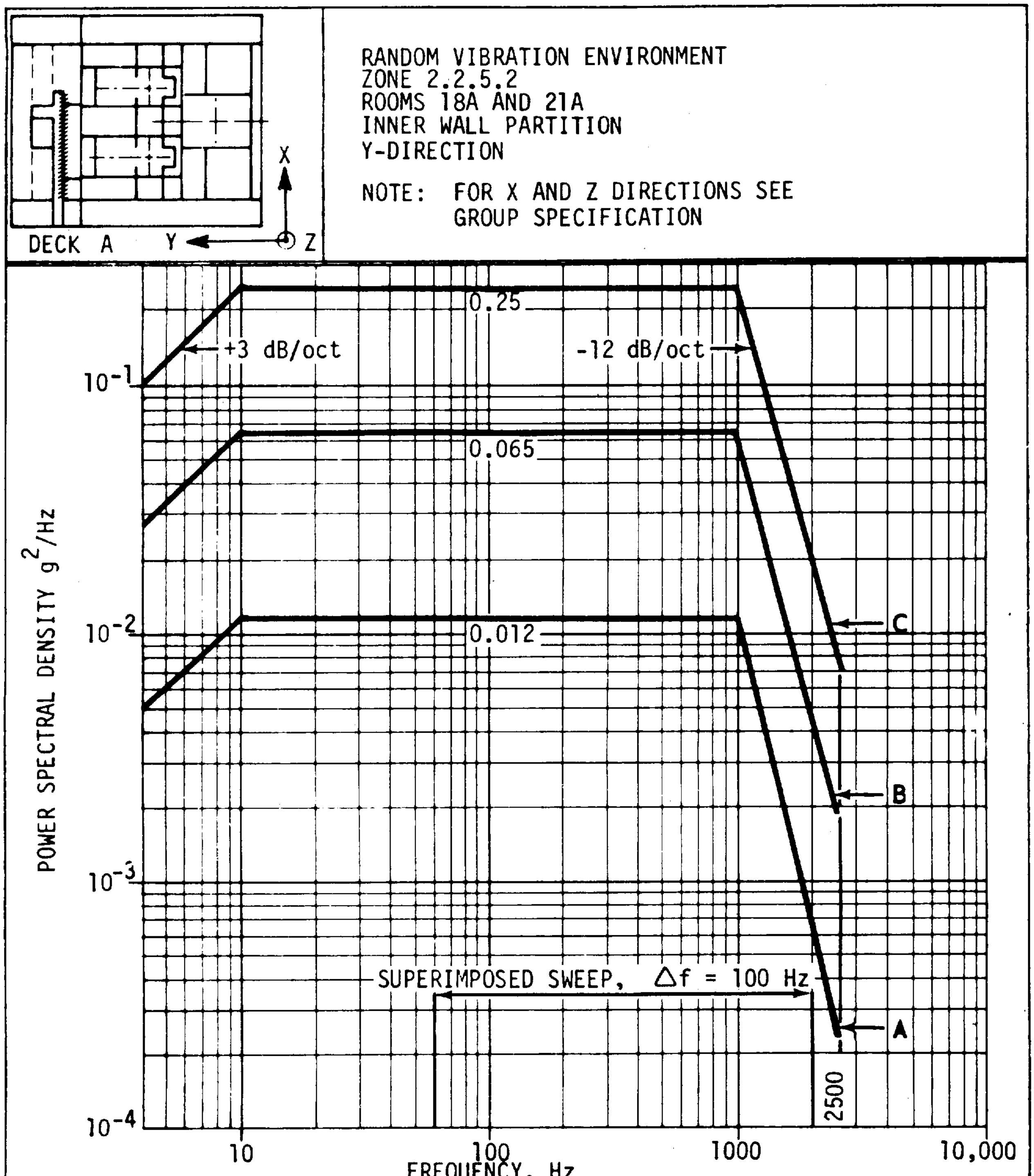


RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.5.2
ROOMS 18A AND 21A
INNER WALL PARTITIONS
X-DIRECTION

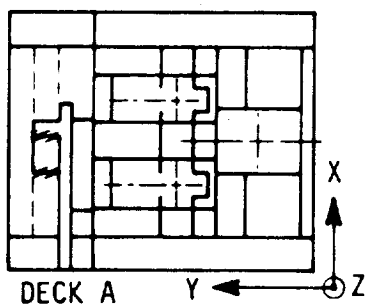
NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION



Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.03	4.3
B	Lift-off Steady State Until Umbilical Disconnect	0.16	10.0
C	Lift-off Peak	0.3	18.9

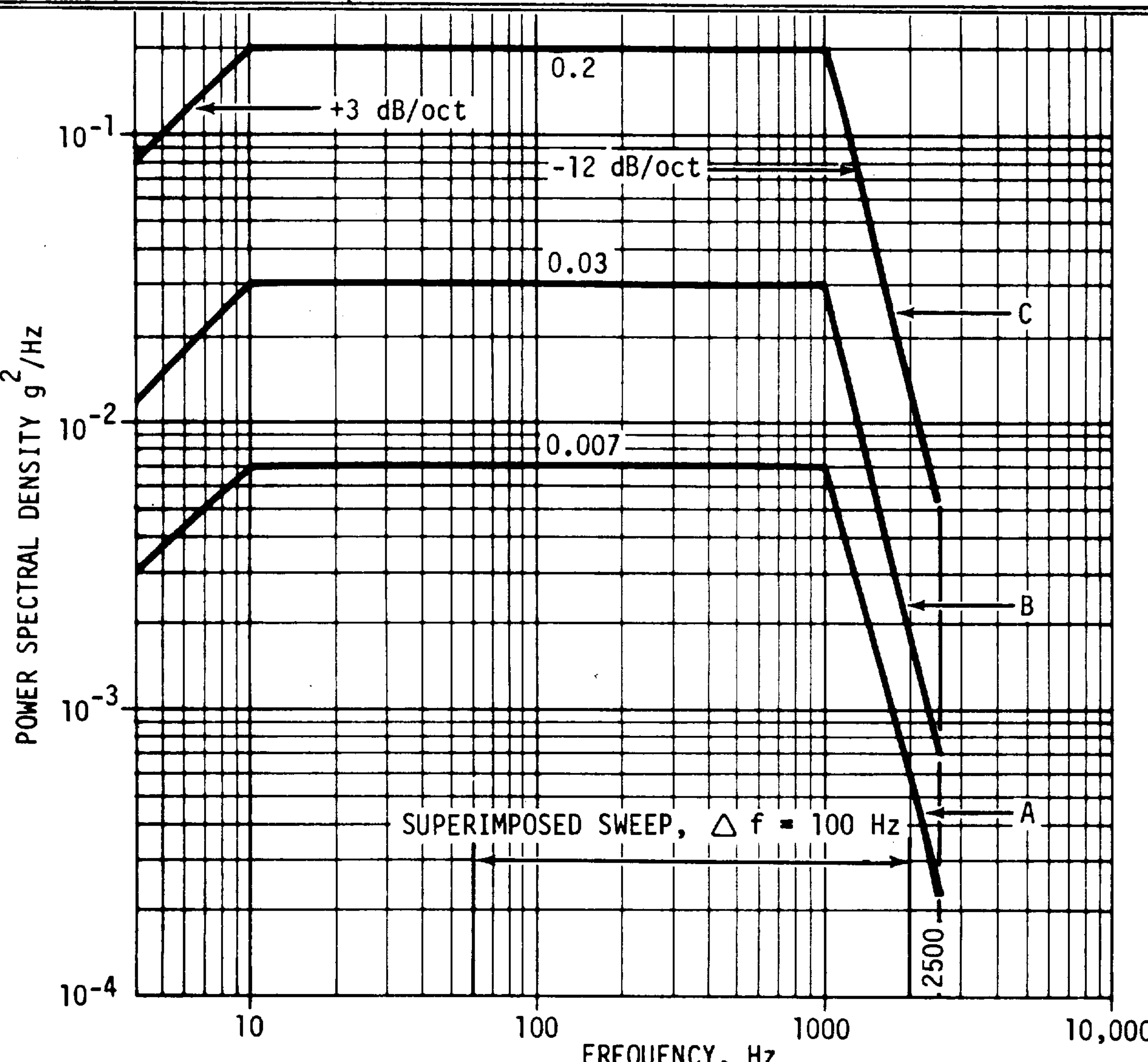


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.03	4.3
B	Lift-off Steady State Until Umbilical Disconnect	0.16	10.0
C	Lift-off Peak	0.3	18.9

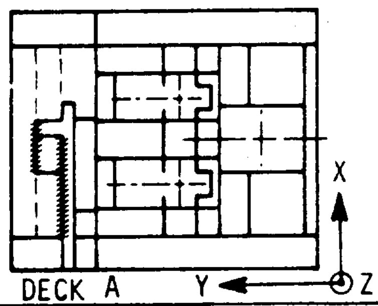


RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.5.3
ROOMS 10A AND 20A
INNER WALL PARTITIONS
X-DIRECTION

NOTE: FOR Y AND Z DIRECTIONS SEE GROUP SPECIFICATION

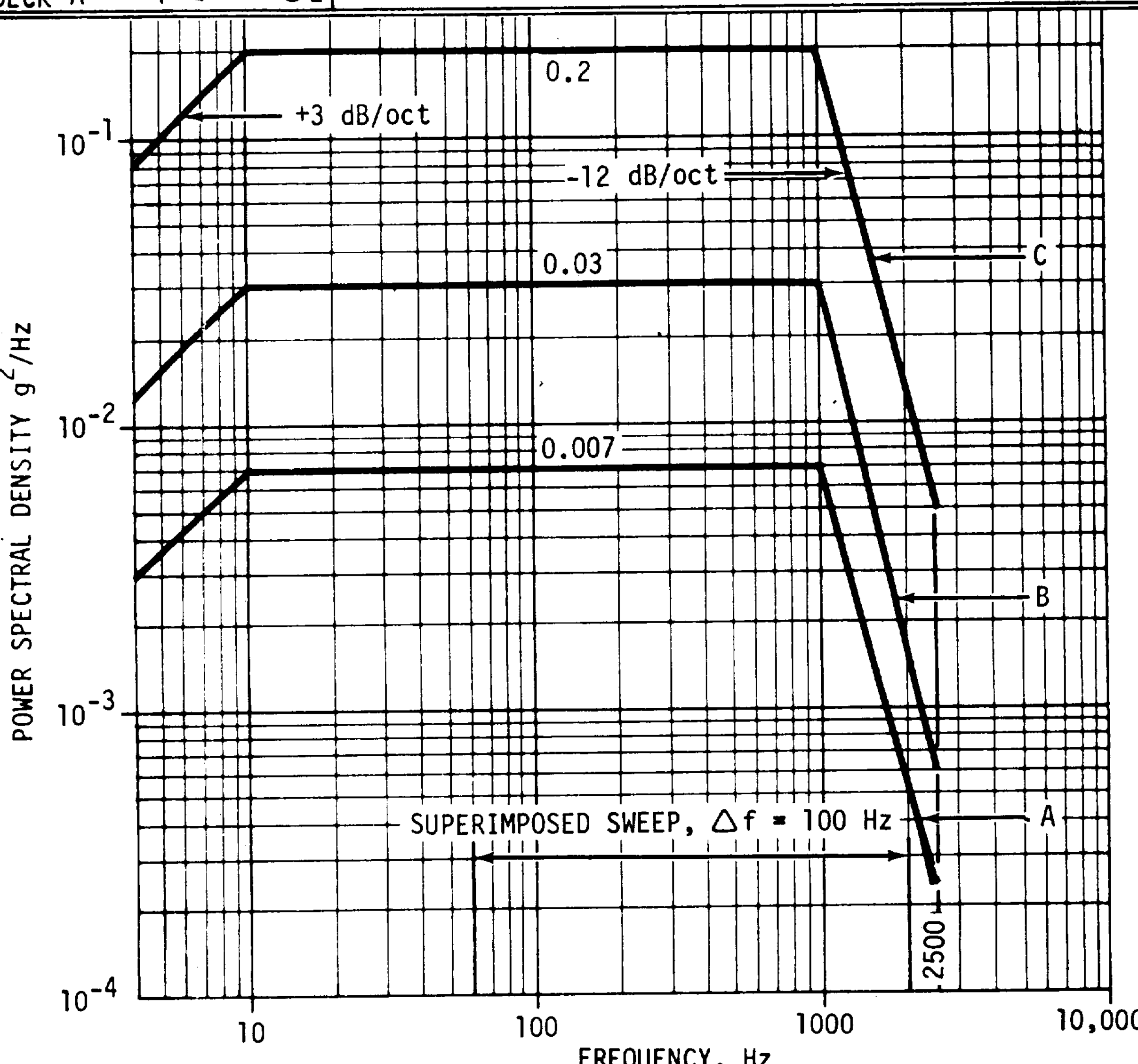


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	3.3
B	Lift-off Steady State Until Umbilical Disconnect	0.08	6.9
C	Lift-off Peak	0.25	16.9

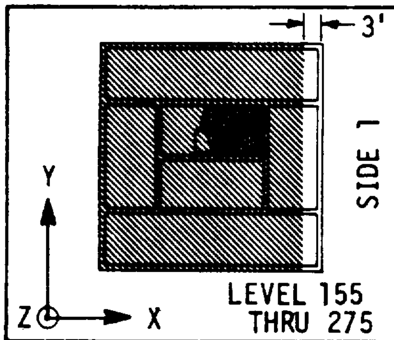


RANDOM VIBRATION ENVIRONMENT
ZONE 2.2.5.3
ROOMS 10A AND 20A
INNER WALL PARTITIONS
Y-DIRECTION

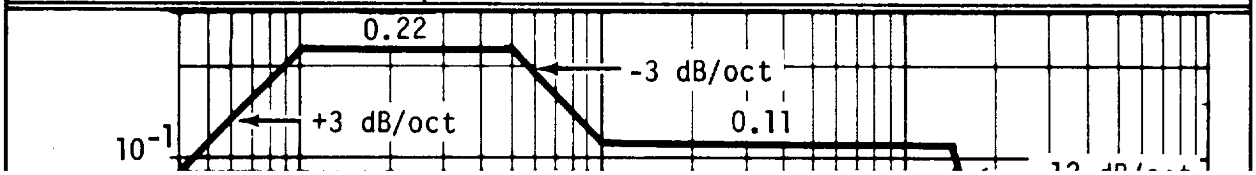
NOTE: FOR X AND Z DIRECTIONS SEE GROUP SPECIFICATION

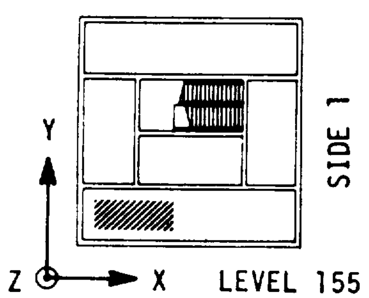


Sym.	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	3.3
B	Lift-off Steady State Until Umbilical Disconnect	0.08	6.9
C	Lift-off Peak	0.25	16.9

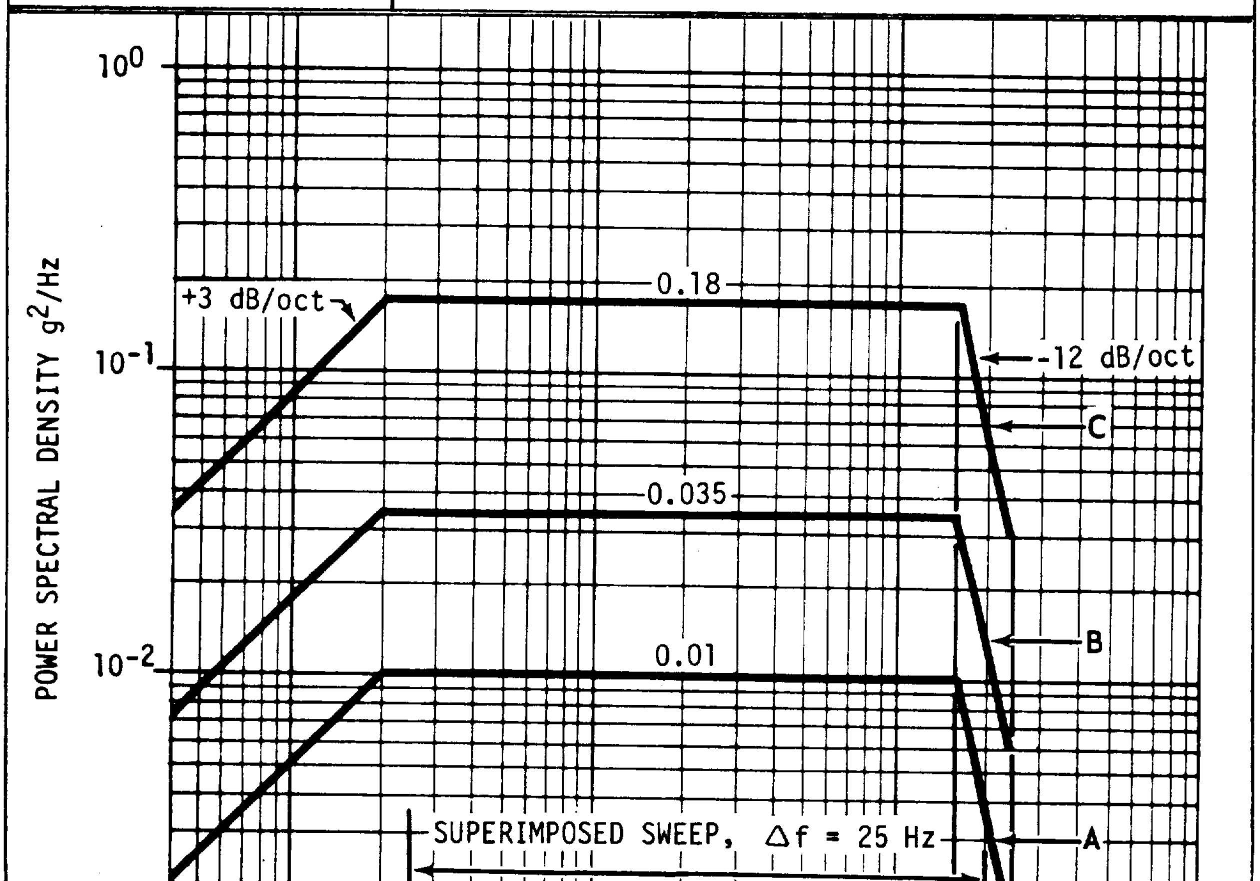


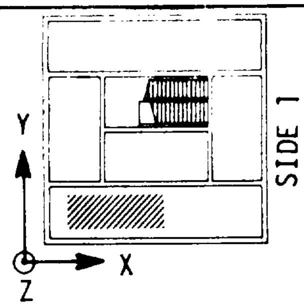
RANDOM VIBRATION ENVIRONMENT
ZONE 3.1.5 THRU 3.1.11
FLOOR BEAM STRUCTURE AND GRATING OUTSIDE
OF 3-FT ZONE ON SIDE 1
Z - DIRECTION





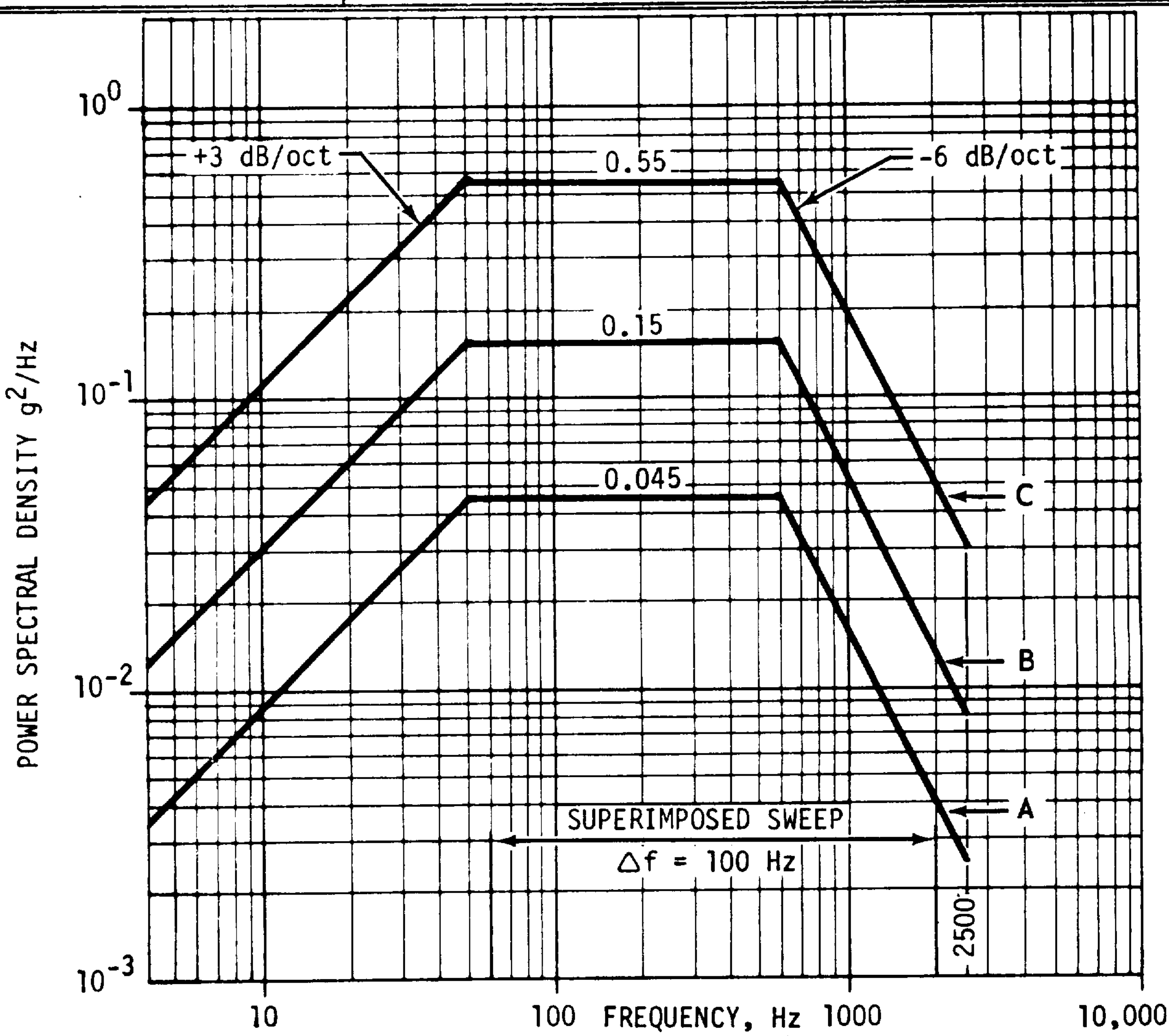
RANDOM VIBRATION ENVIRONMENT
ZONE 3.1.5.2
LH_2 DEWAR AND VALVE COMPLEX
X AND Y DIRECTIONS



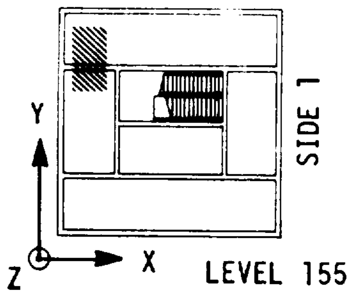


LEVEL 155

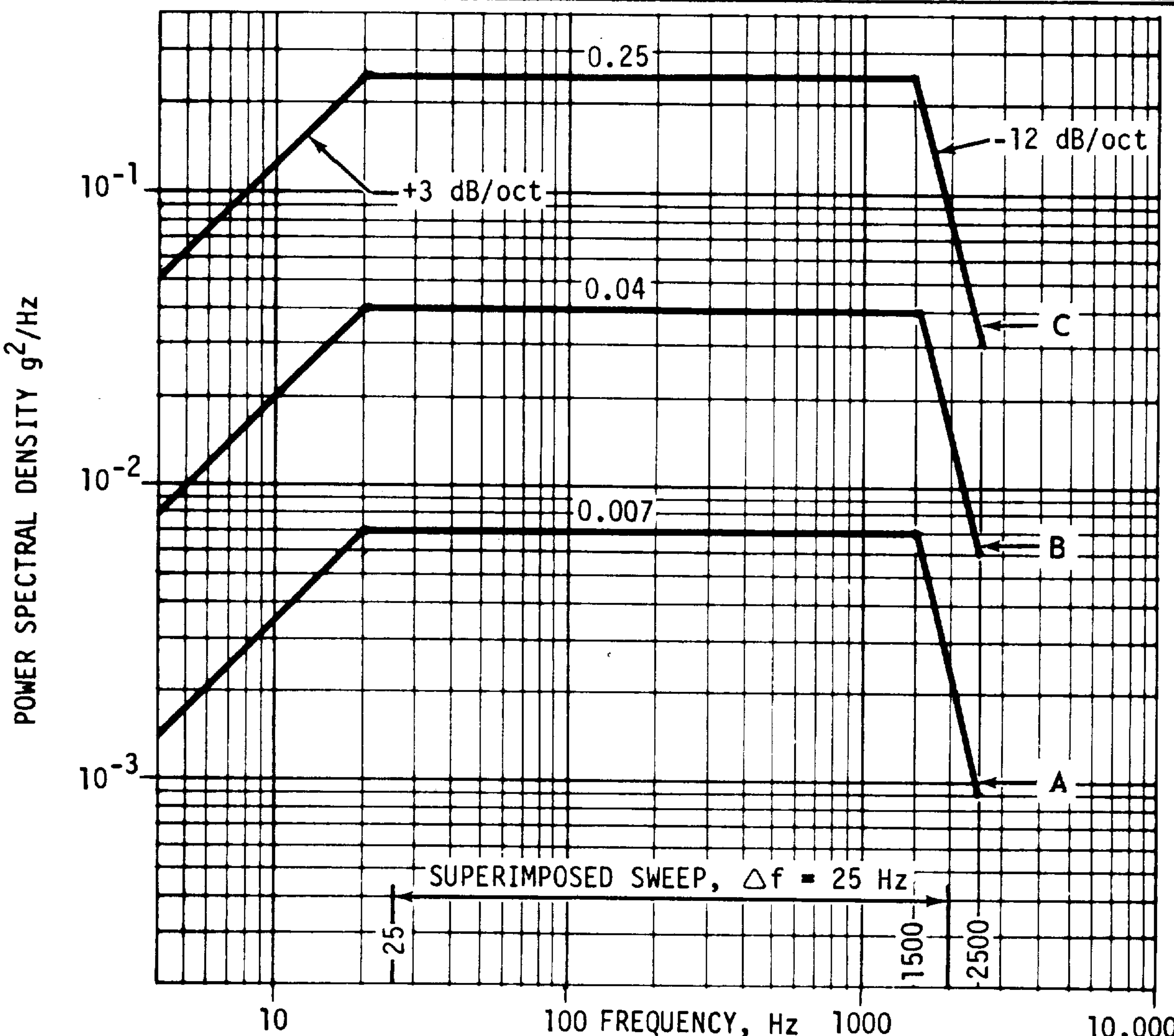
RANDOM VIBRATION ENVIRONMENT
ZONE 3.1.5.2
LH_2 DEWAR AND VALVE COMPLEX
Z - DIRECTION



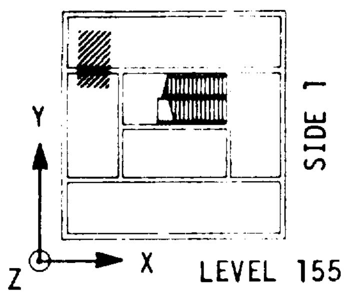
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.10	7.5
B	Lift-off Steady State Until Umbilical Disconnect	0.30	13.6
C	Lift-off Peak	0.60	25.0



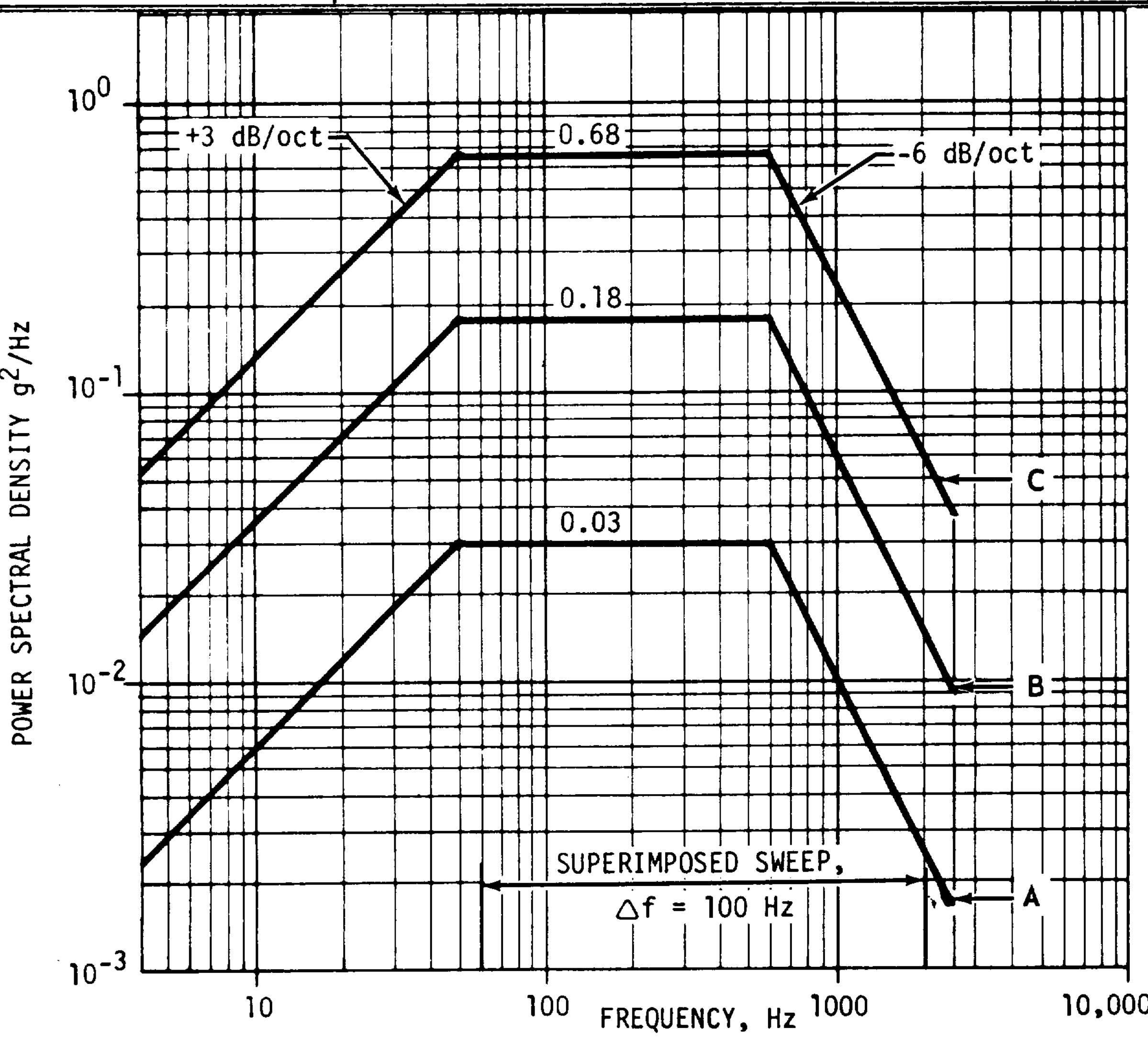
RANDOM VIBRATION ENVIRONMENT
ZONE 3.1.5.3
LOX DEWAR AND VALVE COMPLEX
X AND Y DIRECTIONS



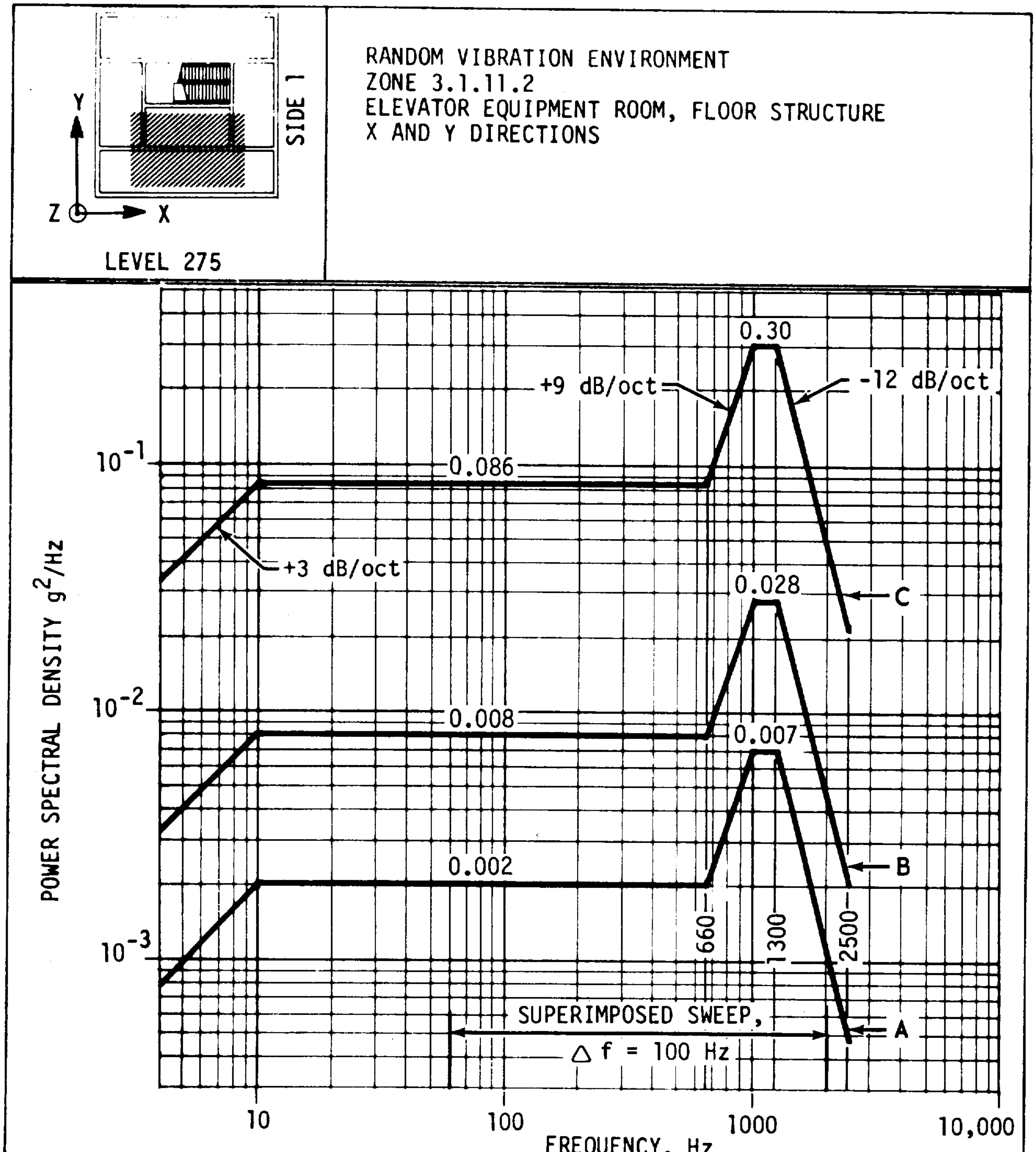
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.10	4.0
B	Lift-off Steady State Until Umbilical Disconnect	0.20	9.0
C	Lift-off Peak	0.70	22.1



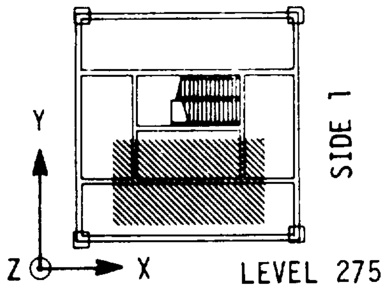
RANDOM VIBRATION ENVIRONMENT
ZONE 3.1.5.3
LOX DEWAR AND VALVE COMPLEX
Z - DIRECTION



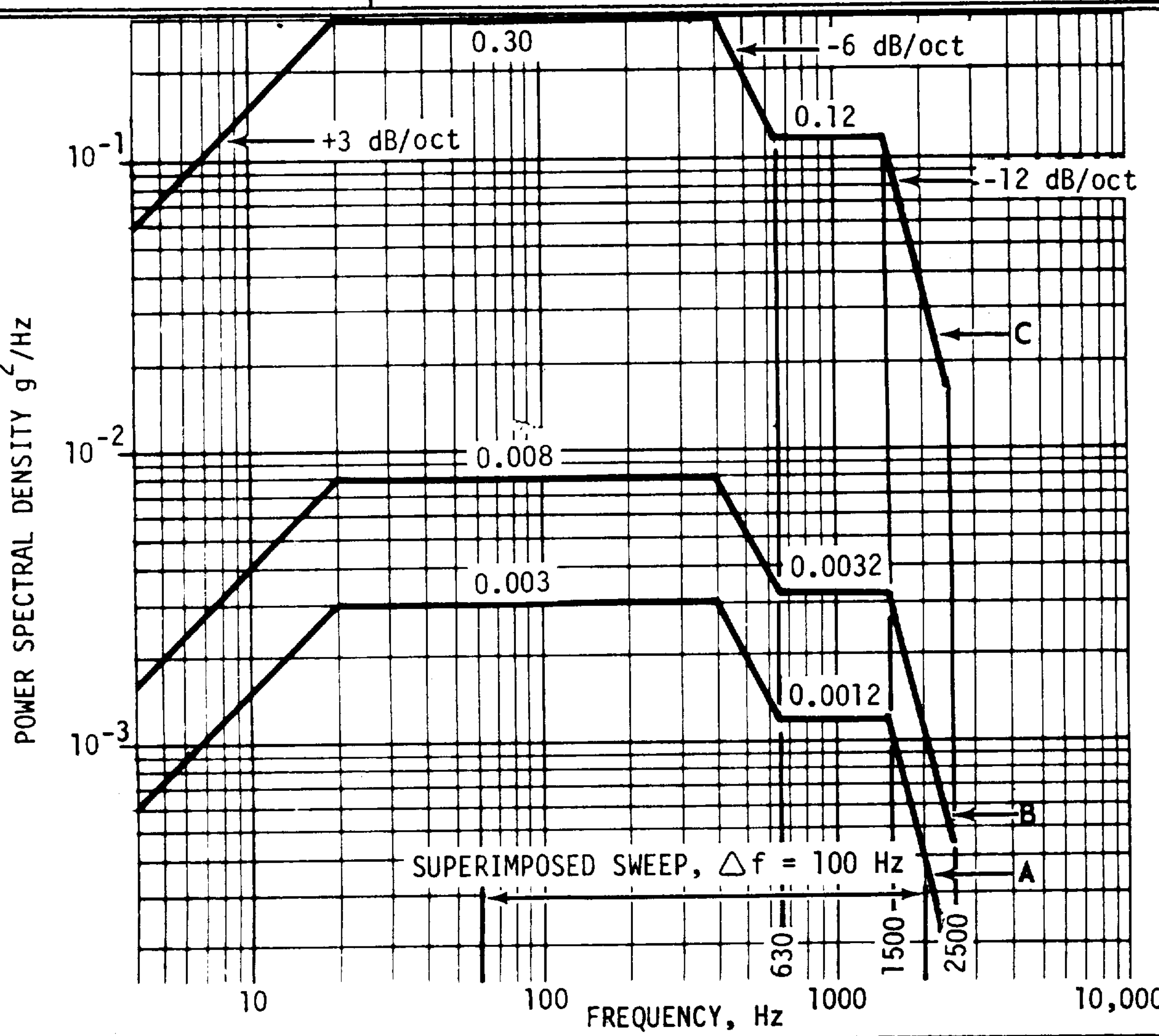
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.10	6.4
B	Lift-off Steady State Until Umbilical Disconnect	0.30	14.7
C	Lift-off Peak	0.70	27.8



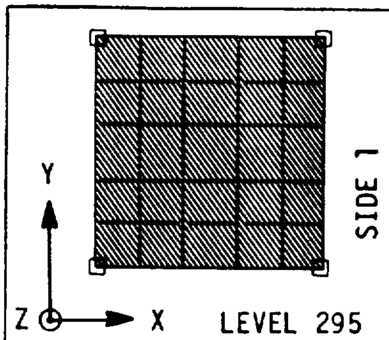
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.012	2.9
B	Lift-off Steady State Until Umbilical Disconnect	0.03	5.7
C	Lift-off Peak	0.30	18.7



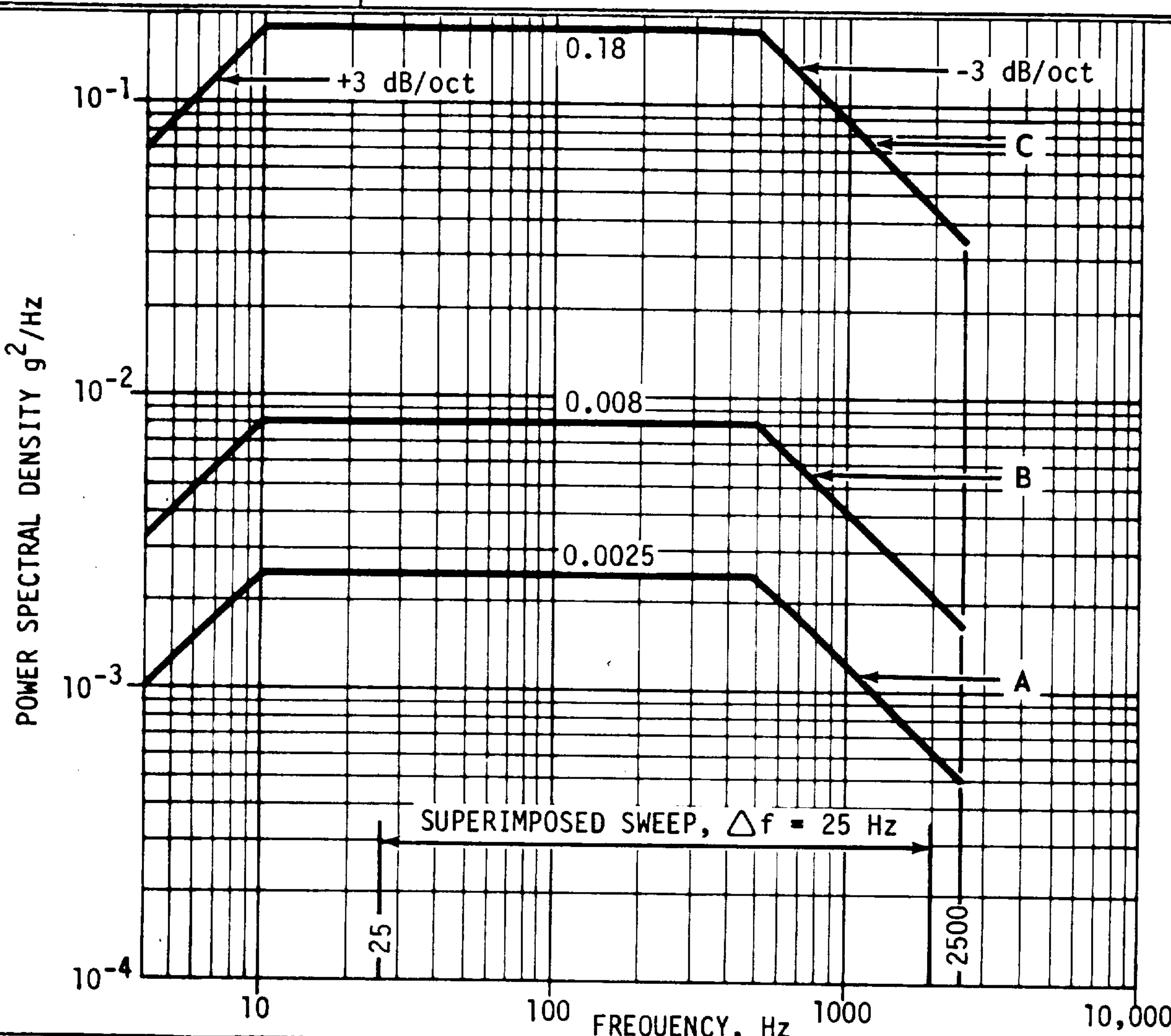
RANDOM VIBRATION ENVIRONMENT
ZONE 3.1.11.2
ELEVATOR EQUIPMENT ROOM, FLOOR STRUCTURE
Z - DIRECTION



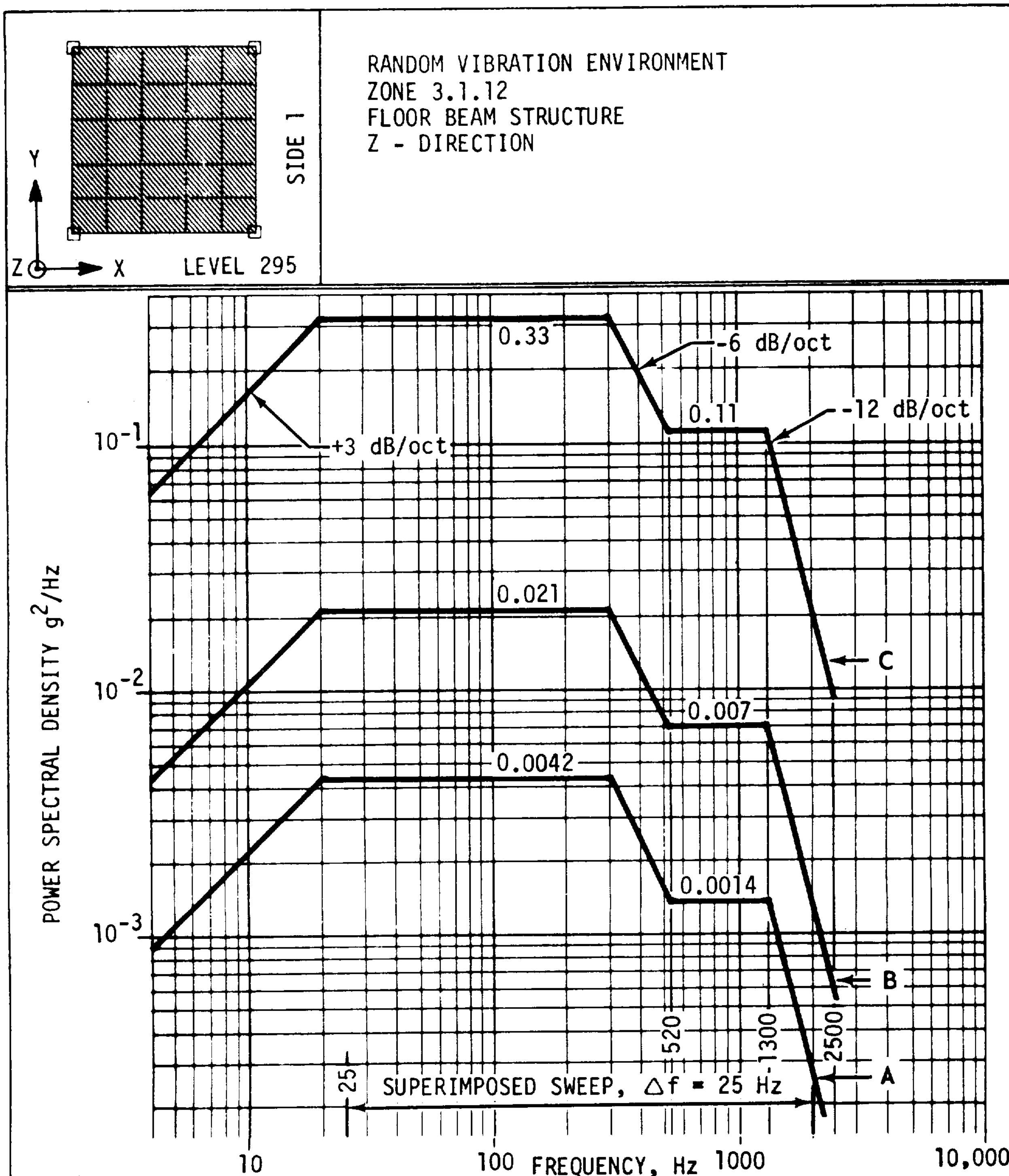
Sym.	Launch Stage	Sweep △ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	2.0
B	Lift-off Steady State Until Umbilical Disconnect	0.015	3.1
C	Lift-off Peak	0.5	19.0



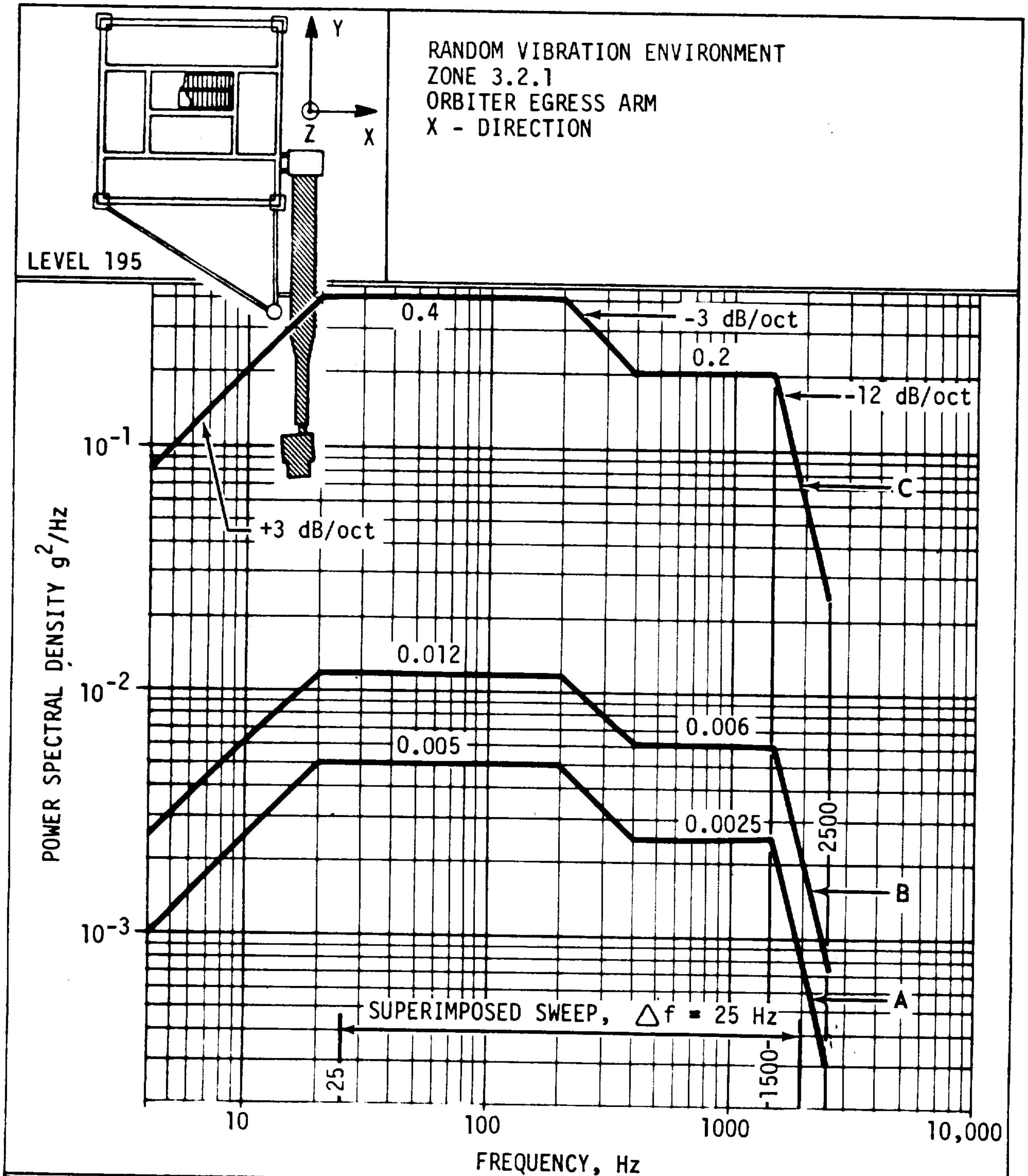
RANDOM VIBRATION ENVIRONMENT
ZONE 3.1.12
FLOOR BEAM STRUCTURE
X AND Y DIRECTIONS



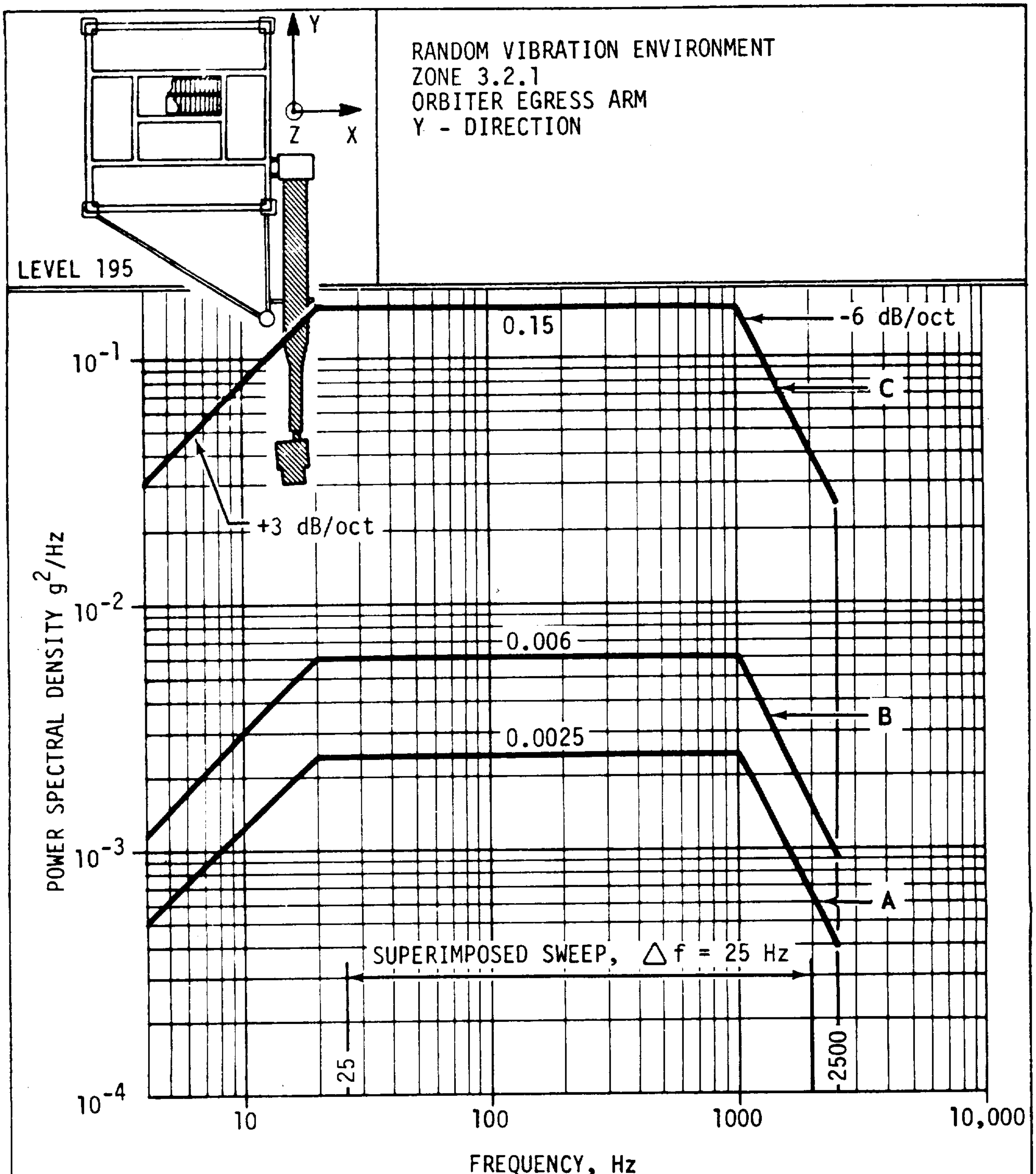
Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.9
B	Lift-off Steady State Until Umbilical Disconnect	0.08	3.5
C	Lift-off Peak	0.40	15.6



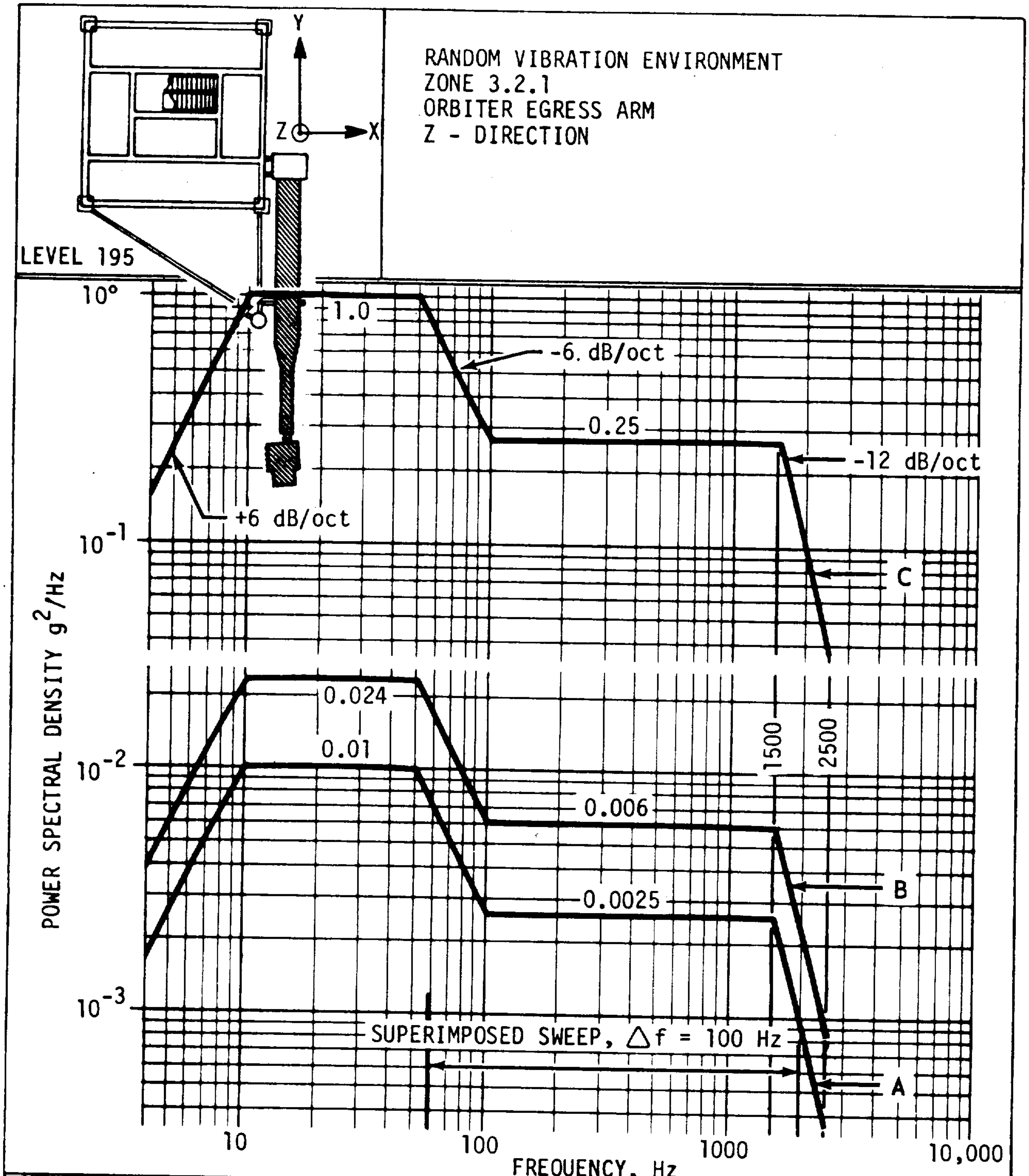
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.08	2.3
B	Lift-off Steady State Until Umbilical Disconnect	0.15	4.5
C	Lift-off Peak	0.50	16.6



Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.07	2.7
B	Lift-off Steady State Until Umbilical Disconnect	0.15	4.1
C	Lift-off Peak	1.0	21.4

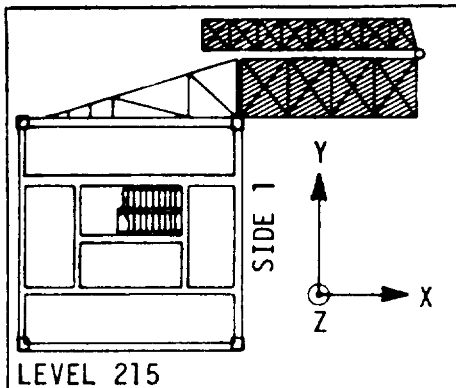


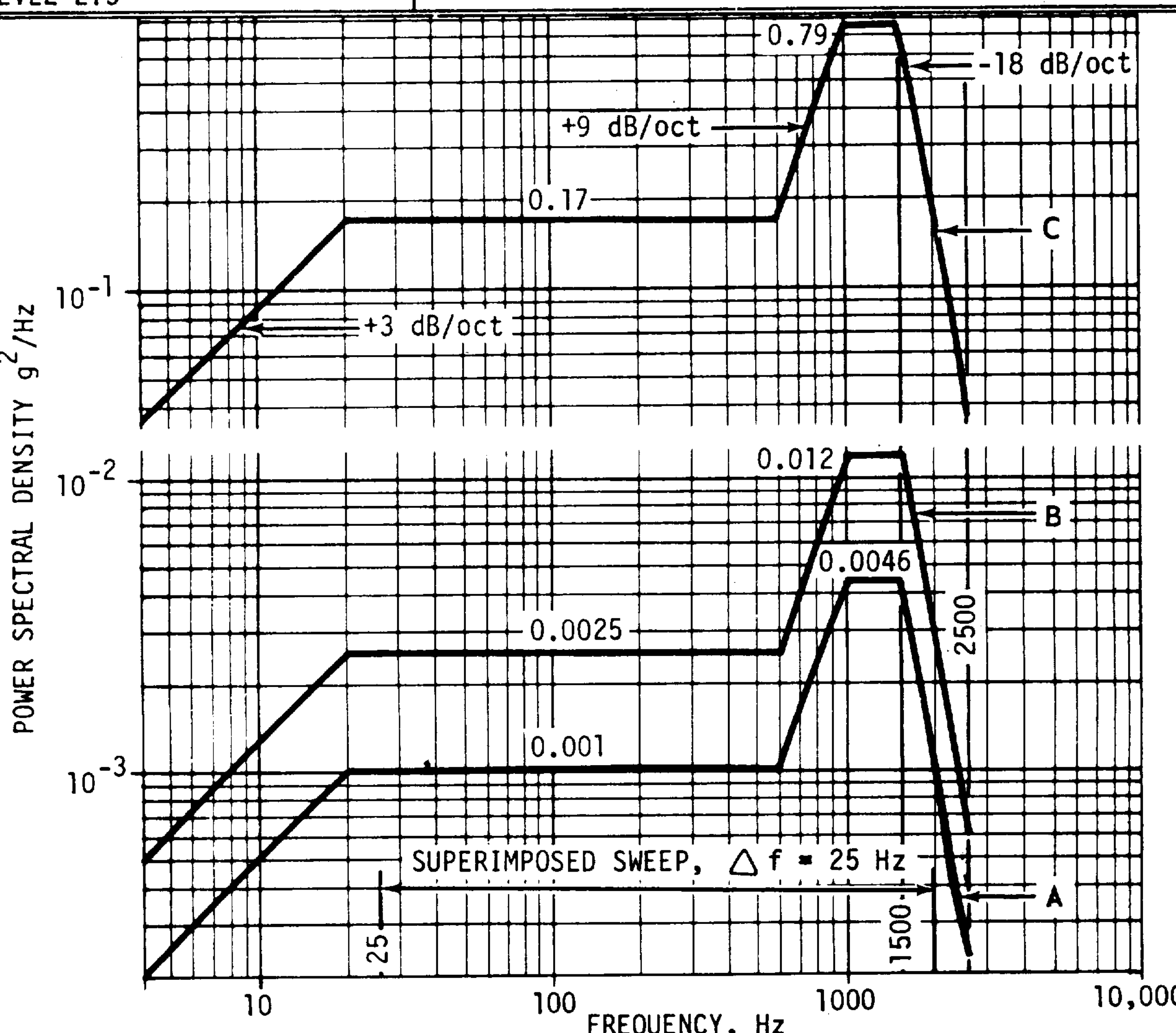
Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.04	2.2
B	Lift-off Steady State Until Umbilical Disconnect	0.10	3.5
C	Lift-off Peak	0.60	15.9



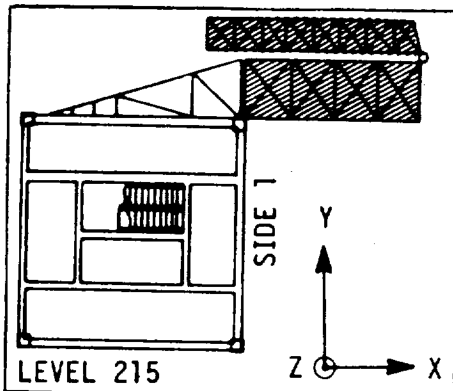
Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.03	2.9
B	Lift-off Steady State Until Umbilical Disconnect	0.06	4.3
C	Lift-off Peak	0.5	23.8

RANDOM VIBRATION ENVIRONMENT
ZONE 3.2.2
INTERTANK ACCESS ARM
X - DIRECTION

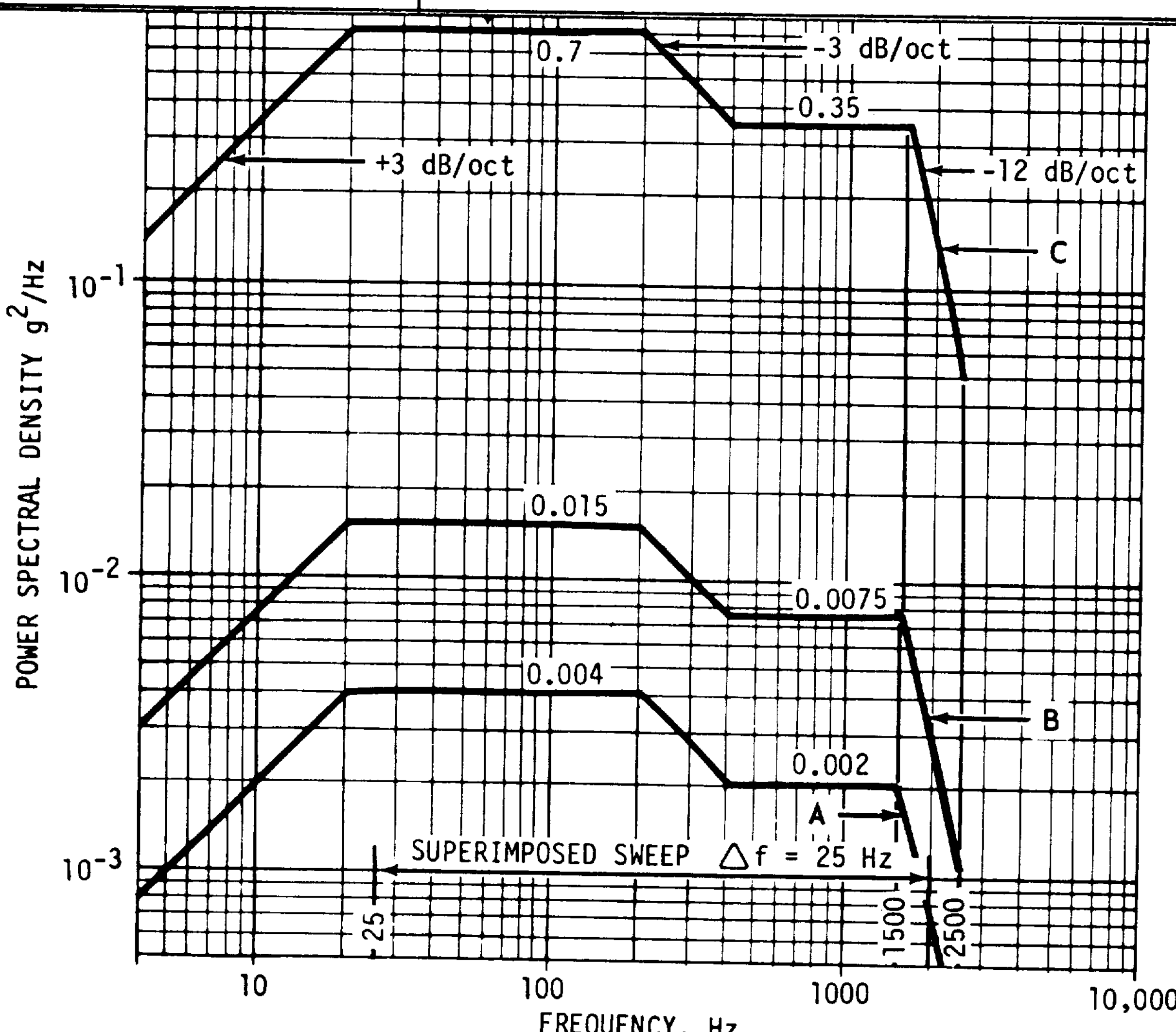




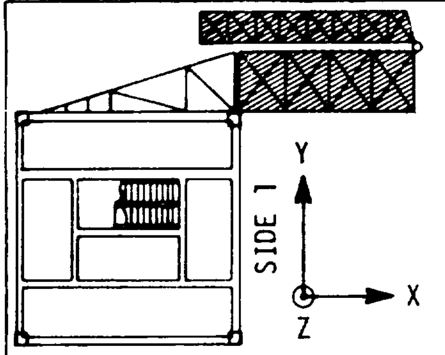
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	2.5
B	Lift-off Steady State Until Umbilical Disconnect	0.15	4.1
C	Lift-off Peak	1.50	30.3



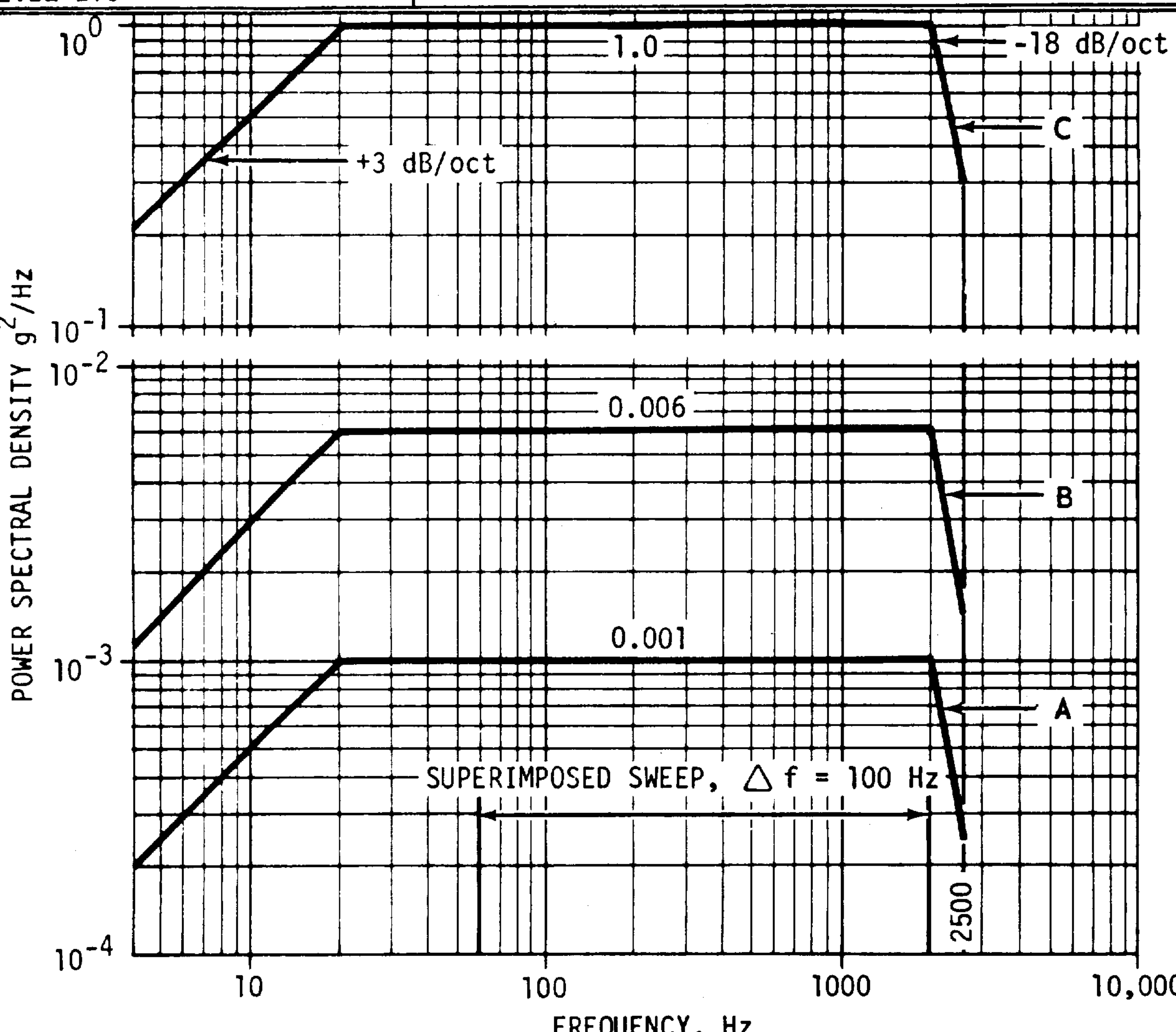
RANDOM VIBRATION ENVIRONMENT
ZONE 3.2.2
INTERTANK ACCESS ARM
Y - DIRECTION



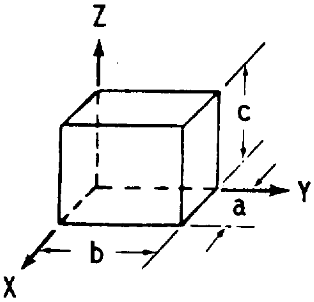
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.07	2.5
B	Lift-off Steady State Until Umbilical Disconnect	0.15	4.5
C	Lift-off Peak	2.0	28.3



RANDOM VIBRATION ENVIRONMENT
ZONE 3.2.2
INTERTANK ACCESS ARM
Z - DIRECTION



Sym.	Launch Stage	Sweep $\Delta PSD\ g^2/Hz$	Overall Level g_{rms}
A	Orbiter Holddown	0.02	2.1
B	Lift-off Steady State Until Umbilical Disconnect	0.06	4.4
C	Lift-off Peak	2.0	49.6



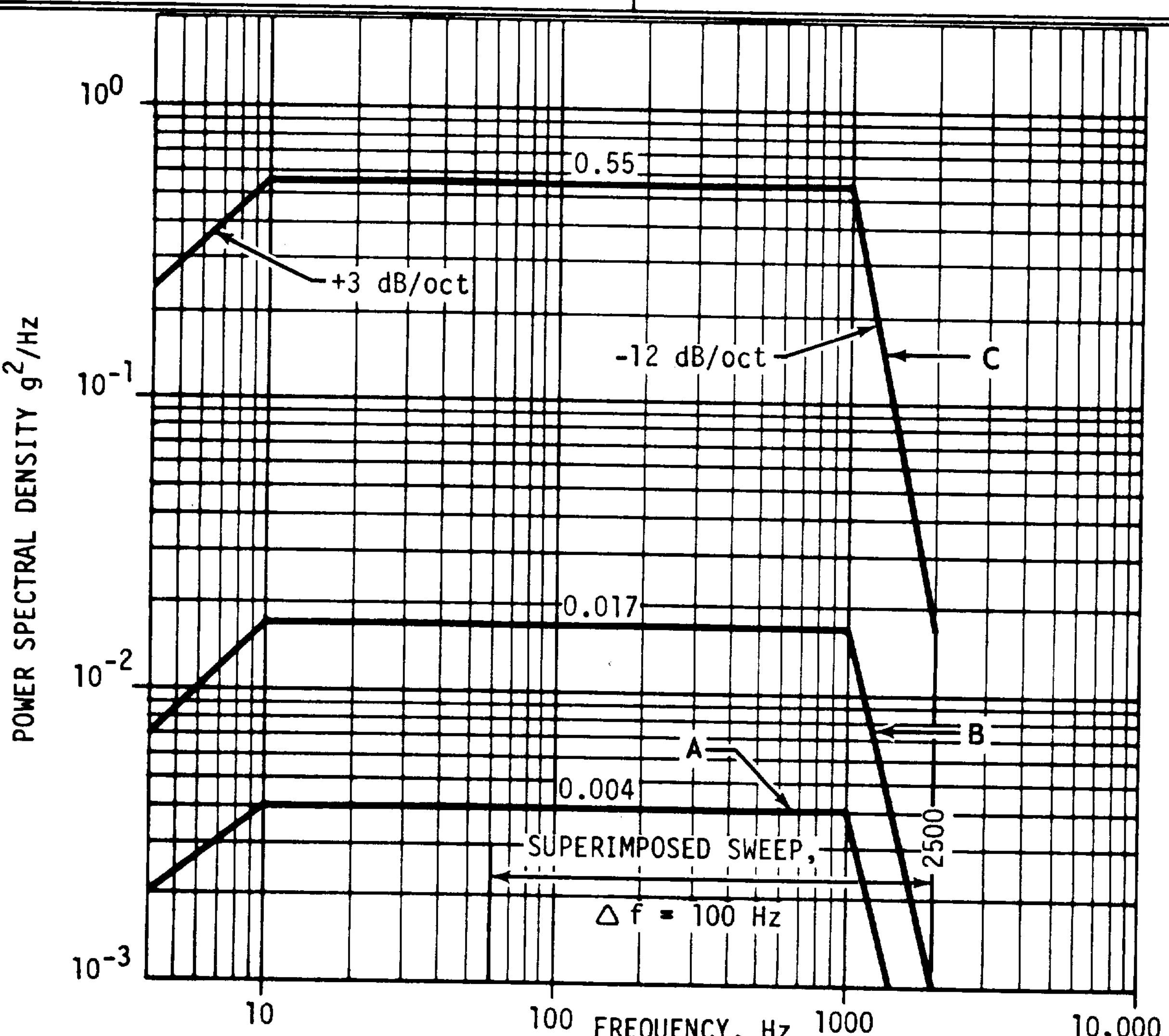
SMALL CABINETS

1'2" < a < 3'3"

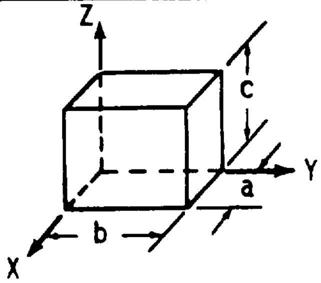
3'0" < b < 6'5"

4'8" < c < 6'0"

RANDOM VIBRATION ENVIRONMENT
ZONES 3.3.1 THROUGH 3.3.3
CABINETS AT LEVELS 75 THROUGH 115
TEST SPECIFICATION FOR VIBRATION
INPUT AT THE BASE OF CABINETS.
X AND Y DIRECTION



Sym.	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.012	2.5
B	Lift-off Steady State Until Umbilical Disconnect	0.05	5.2
C	Lift-off Peak	1.10	28.8



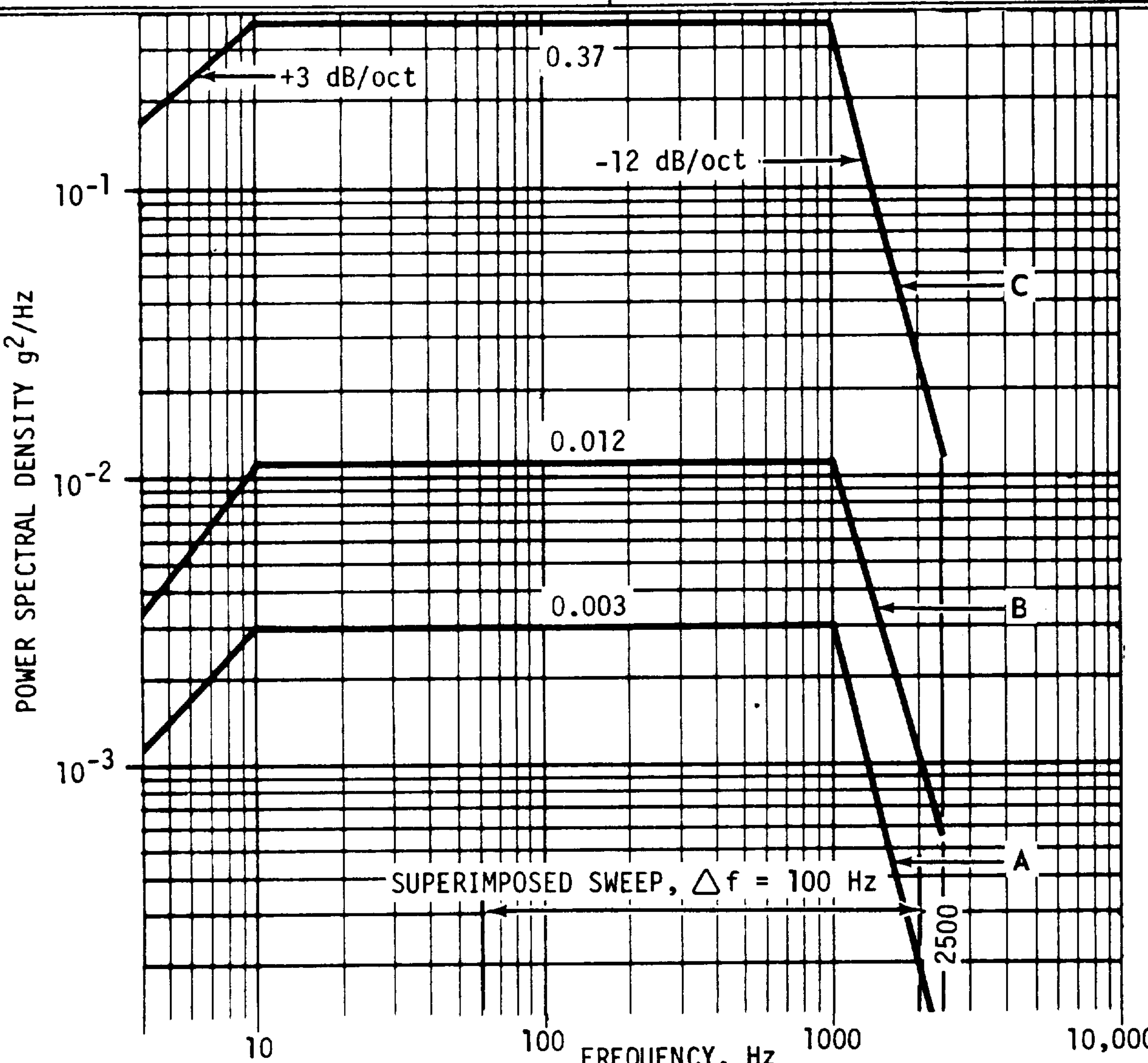
SMALL CABINETS

1'2" < a < 3'3"

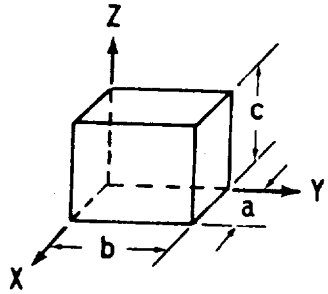
3'0" < b < 6'5"

4'8" < c < 6'0"

RANDOM VIBRATION ENVIRONMENT
ZONE 3.3.1 THROUGH 3.3.3
CABINETS AT LEVELS 75 THROUGH 115
TEST SPECIFICATION FOR VIBRATION
INPUT AT THE BASE OF CABINETS.
Z - DIRECTION



Sym.	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	2.2
B	Lift-off Steady State Until Umbilical Disconnect	0.024	4.3
C	Lift-off Peak	0.74	23.6



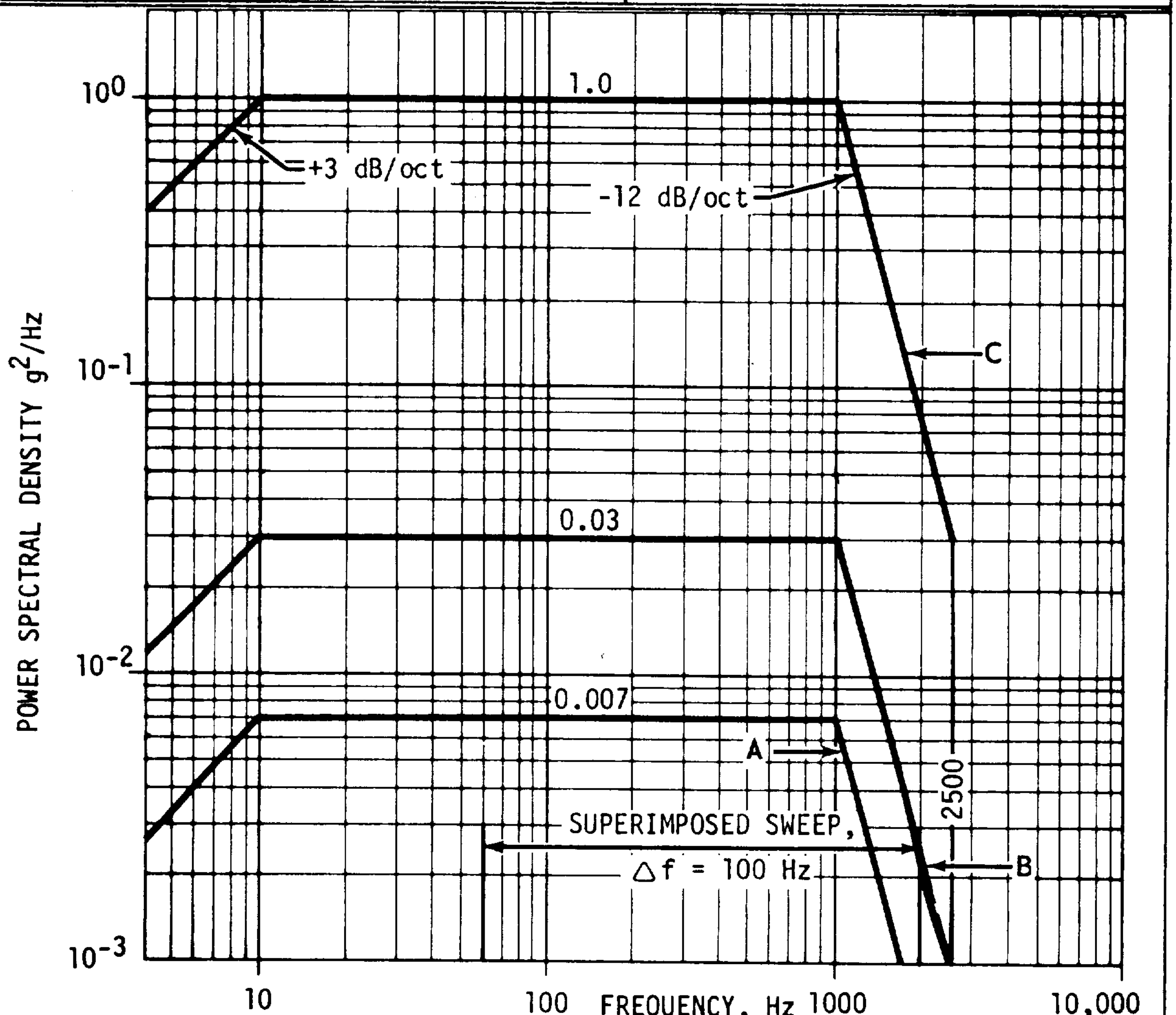
LARGE CABINETS

1'8" < a < 7'2"

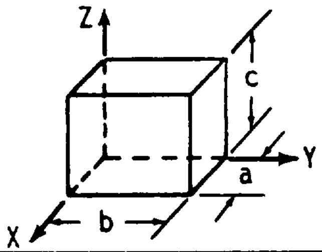
7'8" < b < 10'3"

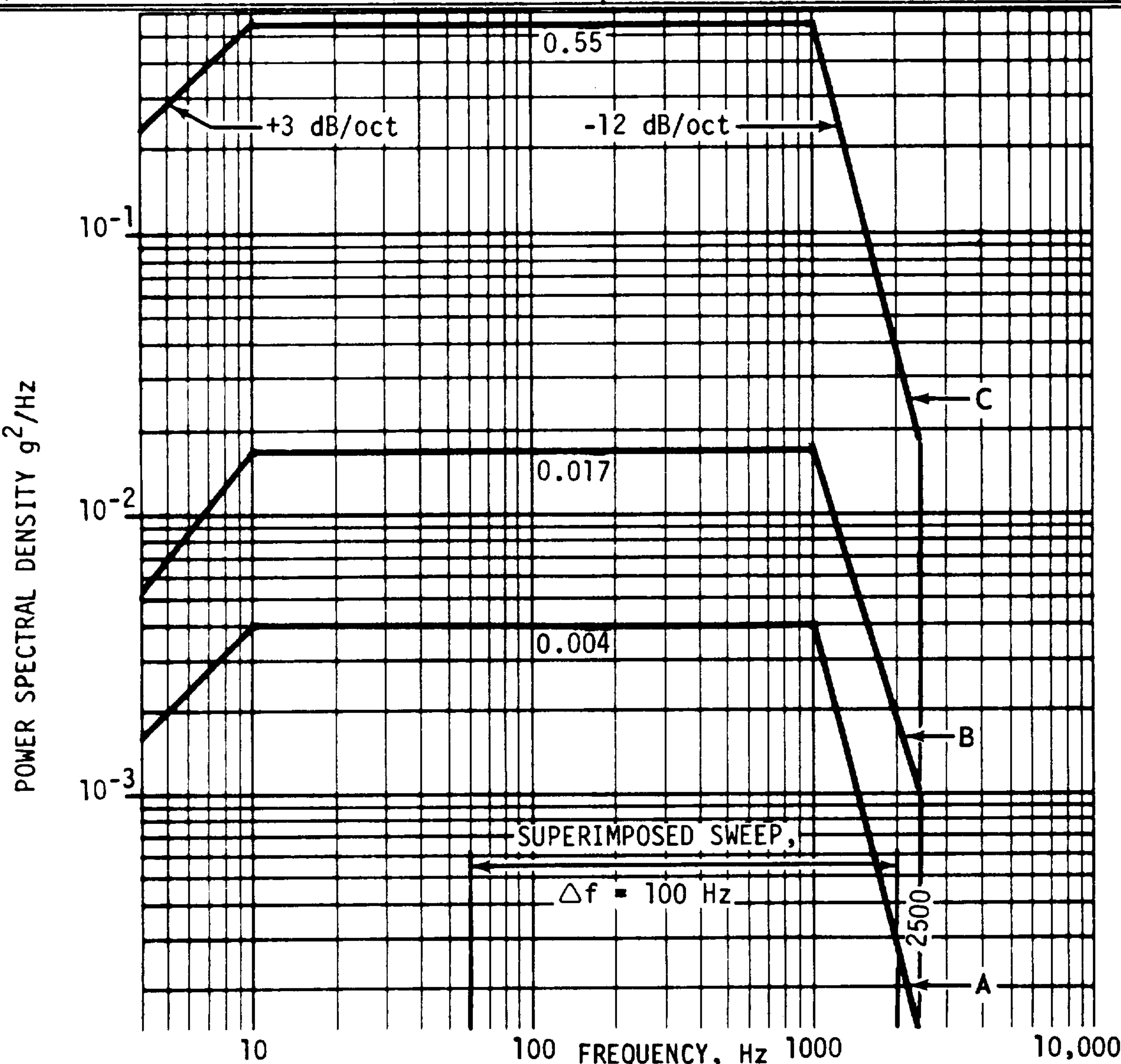
7'6" < c < 8'6"

RANDOM VIBRATION ENVIRONMENT
ZONES 3.3.1 THROUGH 3.3.3
CABINETS AT LEVELS 75 THROUGH 115
TEST SPECIFICATION FOR VIBRATION
INPUT AT THE BASE OF CABINETS.
X AND Y DIRECTION

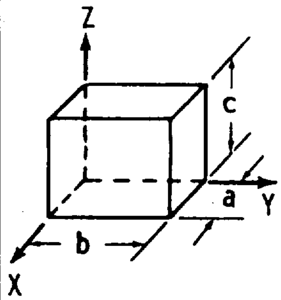


Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	3.2
B	Lift-off Steady State Until Umbilical Disconnect	0.03	6.5
C	Lift-off Peak	1.0	37.5

 LARGE CABINETS 1'8" < a < 7'2" 7'8" < b < 10'3" 7'6" < c < 8'6"	RANDOM VIBRATION ENVIRONMENT ZONE 3.3.1 THROUGH 3.3.3 CABINETS AT LEVELS 75 THROUGH 115 TEST SPECIFICATION FOR VIBRATION INPUT AT THE BASE OF CABINETS. Z - DIRECTION



Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	2.5
B	Lift-off Steady State Until Umbilical Disconnect	0.02	4.9
C	Lift-off Peak	1.1	28.8



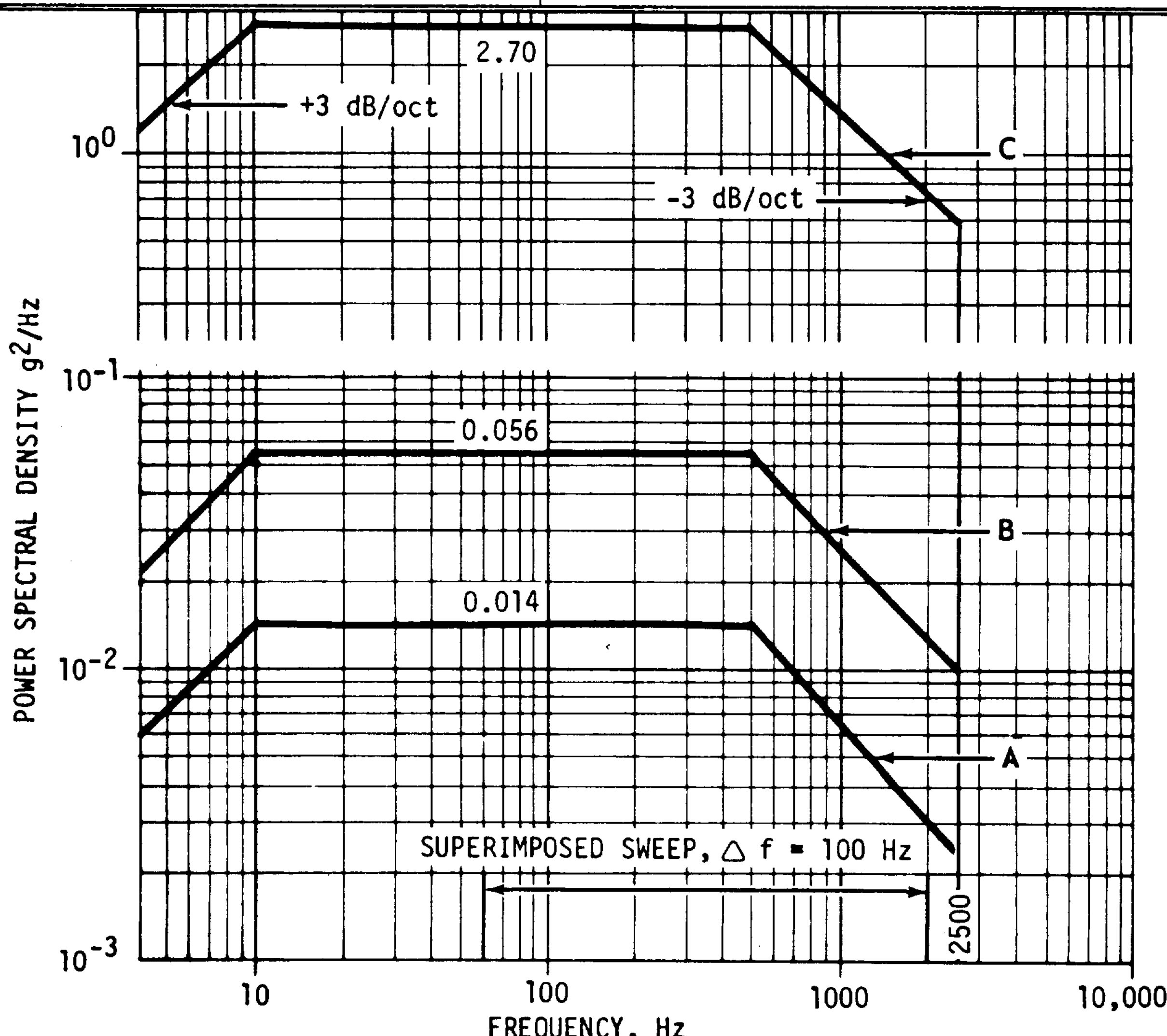
LARGE CABINETS

1'8" < a < 7'2"

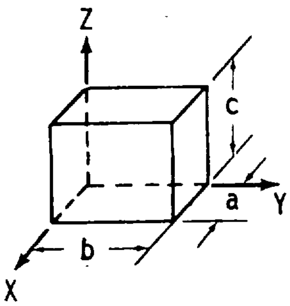
7'8" < b < 10'3"

7'6" < c < 8'6"

RANDOM VIBRATION ENVIRONMENT
ZONES 3.3.1.1 THROUGH 3.3.3.1
CABINETS AT LEVELS 75 THROUGH 115
PREDICTED ENVELOPE OF VIBRATION
OUTPUT AT THE CENTER OF CABINET
TOPS. NOT A TEST SPECIFICATION.
Z - DIRECTION



Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.021	4.5
B	Lift-off Steady State Until Umbilical Disconnect	0.084	9.0
C	Lift-off Peak	4.05	62.5



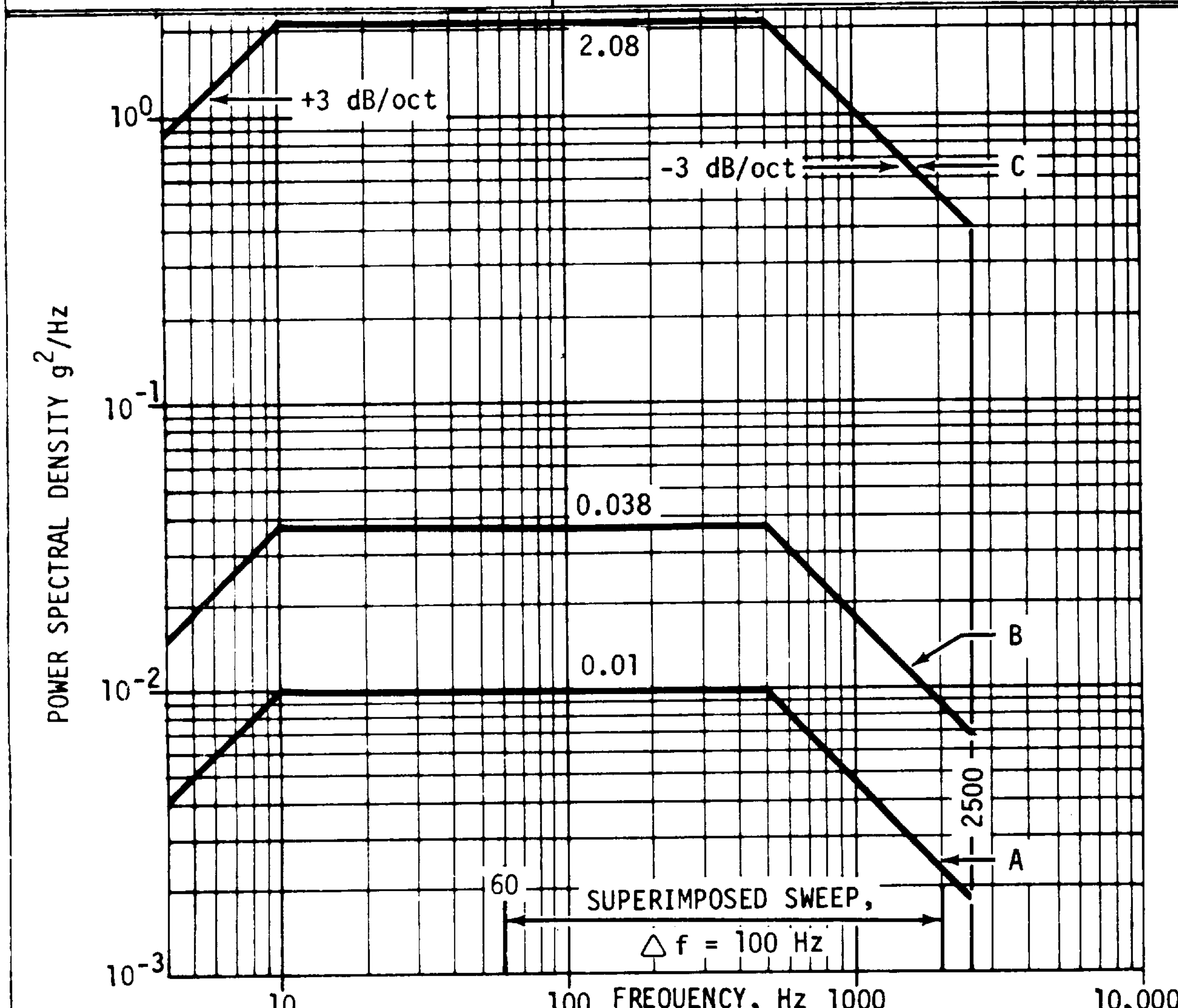
LARGE CABINETS

1'8" < a < 7'2"

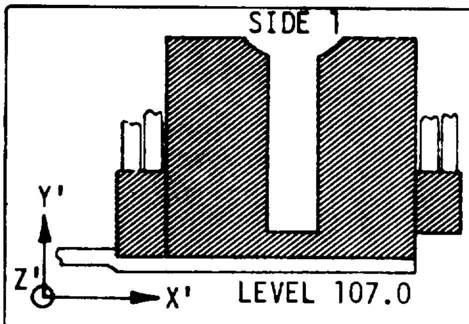
7'8" < b < 10'3"

7'6" < c < 8'6"

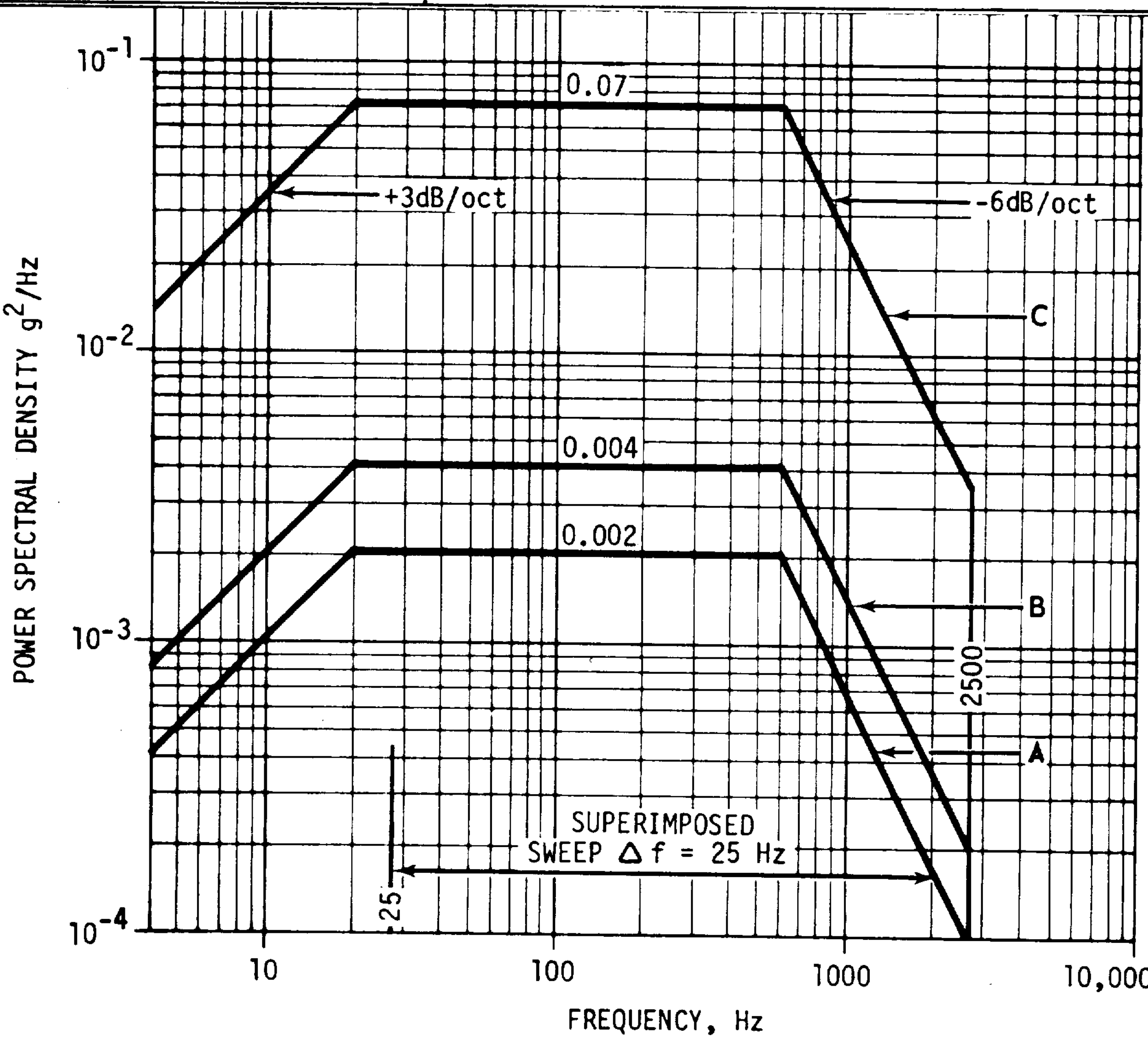
RANDOM VIBRATION ENVIRONMENT
ZONES 3.3.4.1 THROUGH 3.3.11.1
CABINETS AT LEVELS 135 THROUGH 275
PREDICTED ENVELOPE OF VIBRATION
OUTPUT AT THE CENTER OF CABINET
TOPS. NOT A TEST SPECIFICATION.
Z - DIRECTION



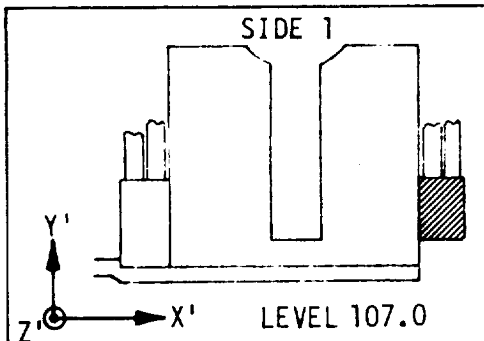
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	3.9
B	Lift-off Steady State Until Umbilical Disconnect	0.095	7.7
C	Lift-off Peak	6.0	57.5



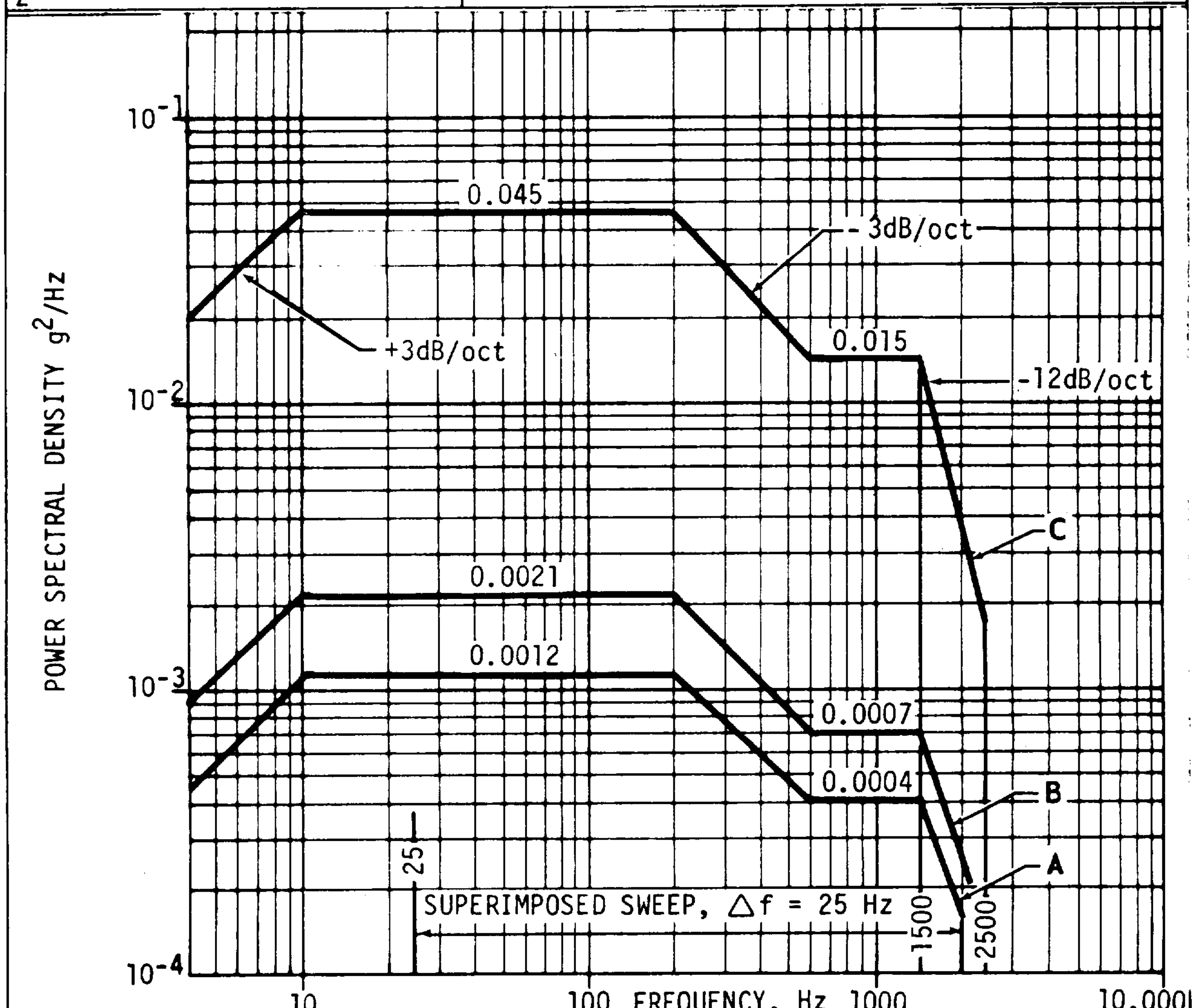
RANDOM VIBRATION ENVIRONMENT
ZONES 4.1.1, 4.1.2 AND 4.1.3
APS SERVICING AND OUTSIDE PLATFORMS
X' AND Y' DIRECTIONS



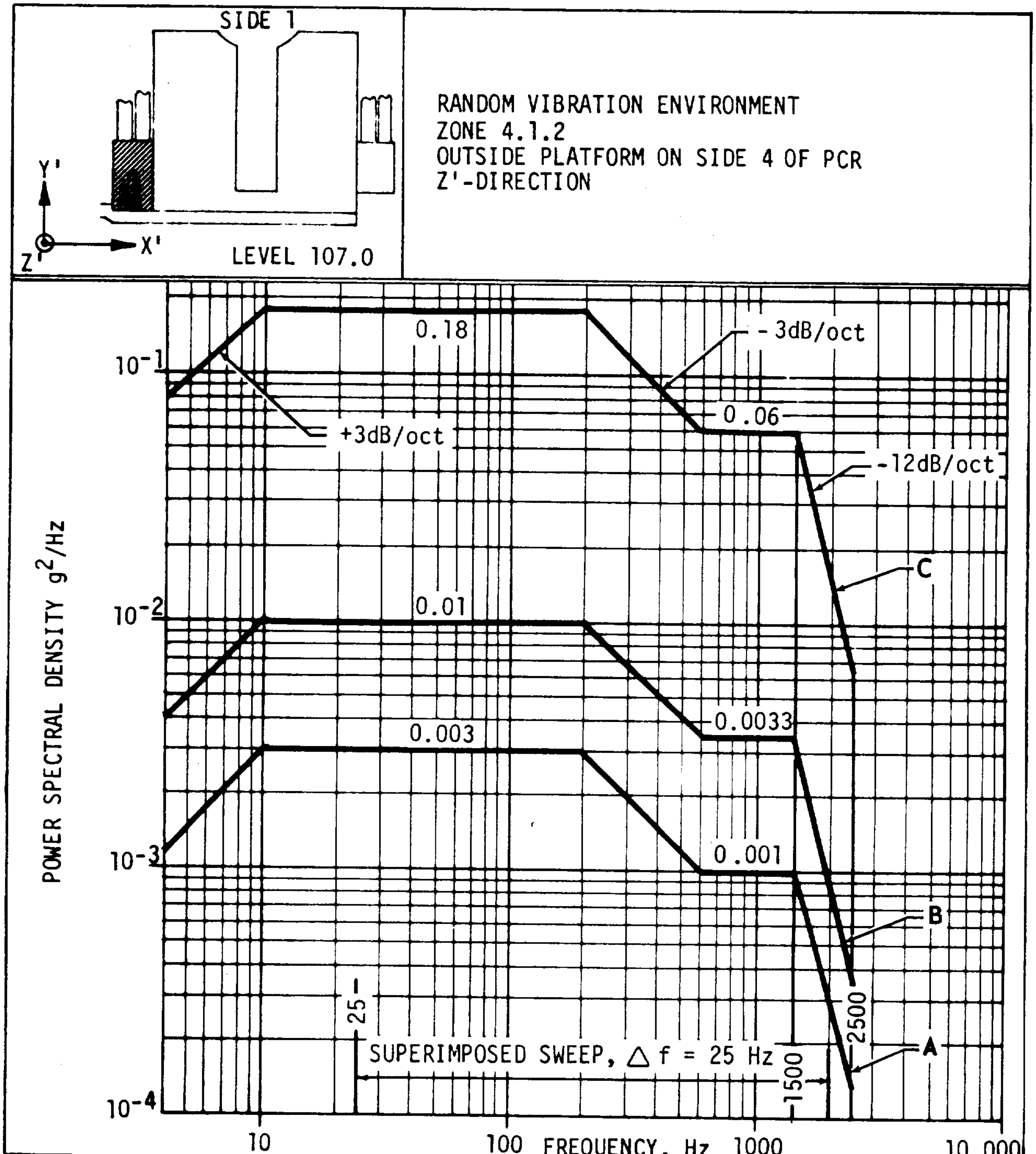
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.5
B	Lift-off Steady State Until Umbilical Disconnect	0.02	2.2
C	Lift-off Peak	0.20	8.8



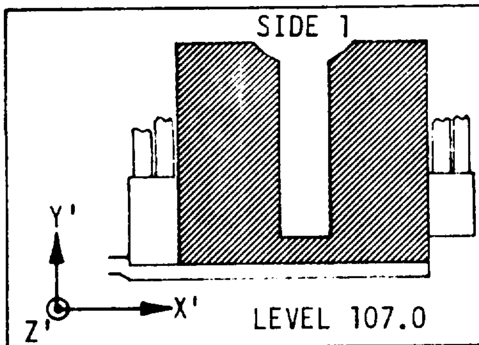
RANDOM VIBRATION ENVIRONMENT
ZONE 4.1.1
OUTSIDE PLATFORM ON SIDE 2 OF PCR
Z'-DIRECTION



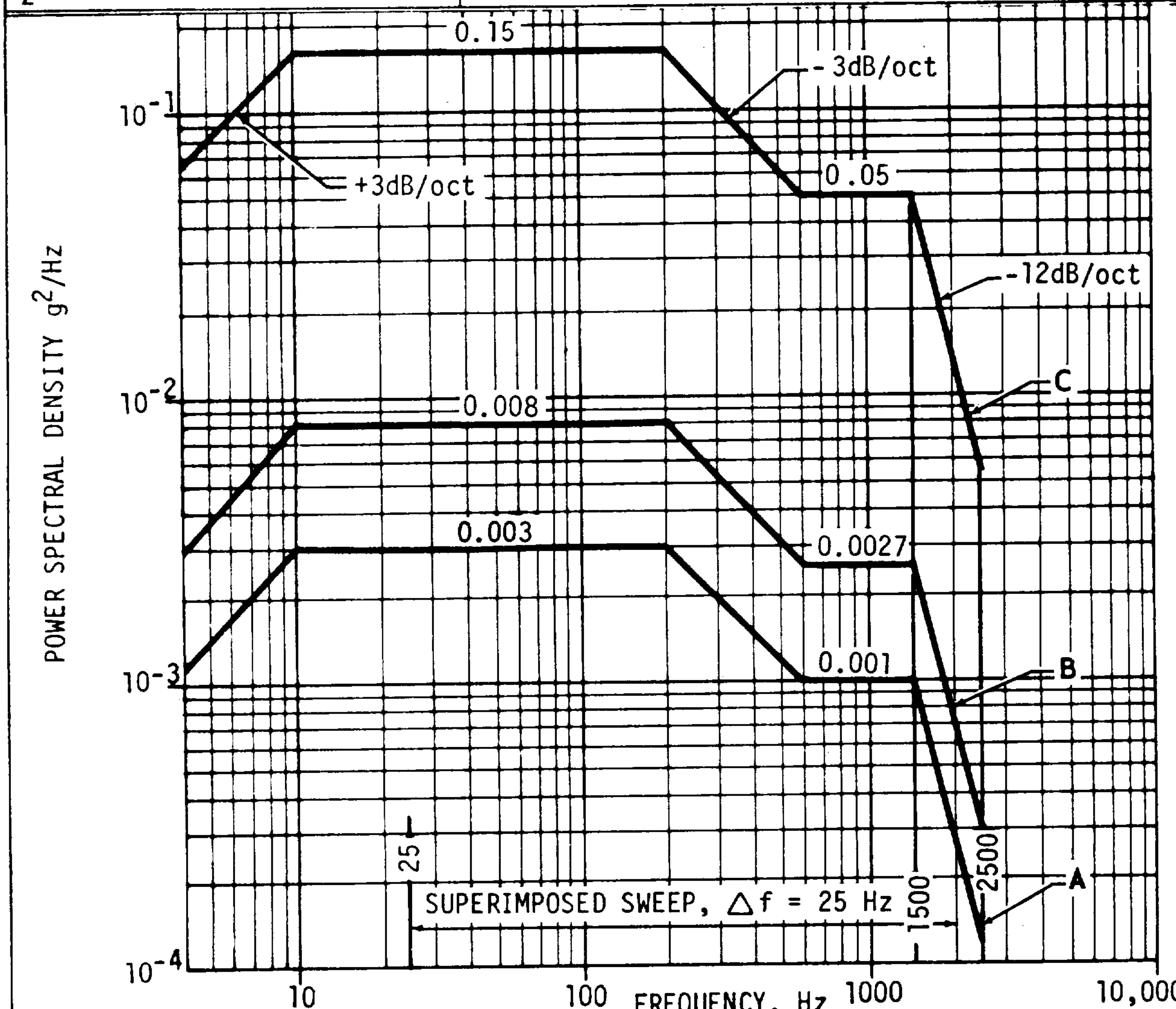
Sym	Launch Stage	Sweep △ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.1
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.5
C	Lift-off Peak	0.1	6.4



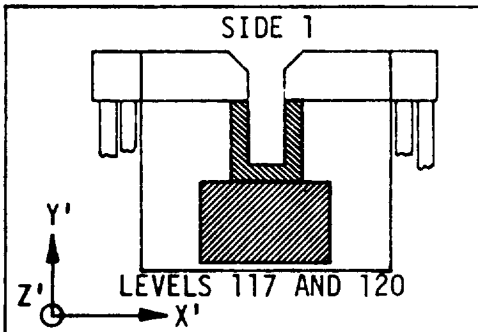
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.7
B	Lift-off Steady State Until Umbilical Disconnect	0.04	3.1
C	Lift-off Peak	0.30	12.6



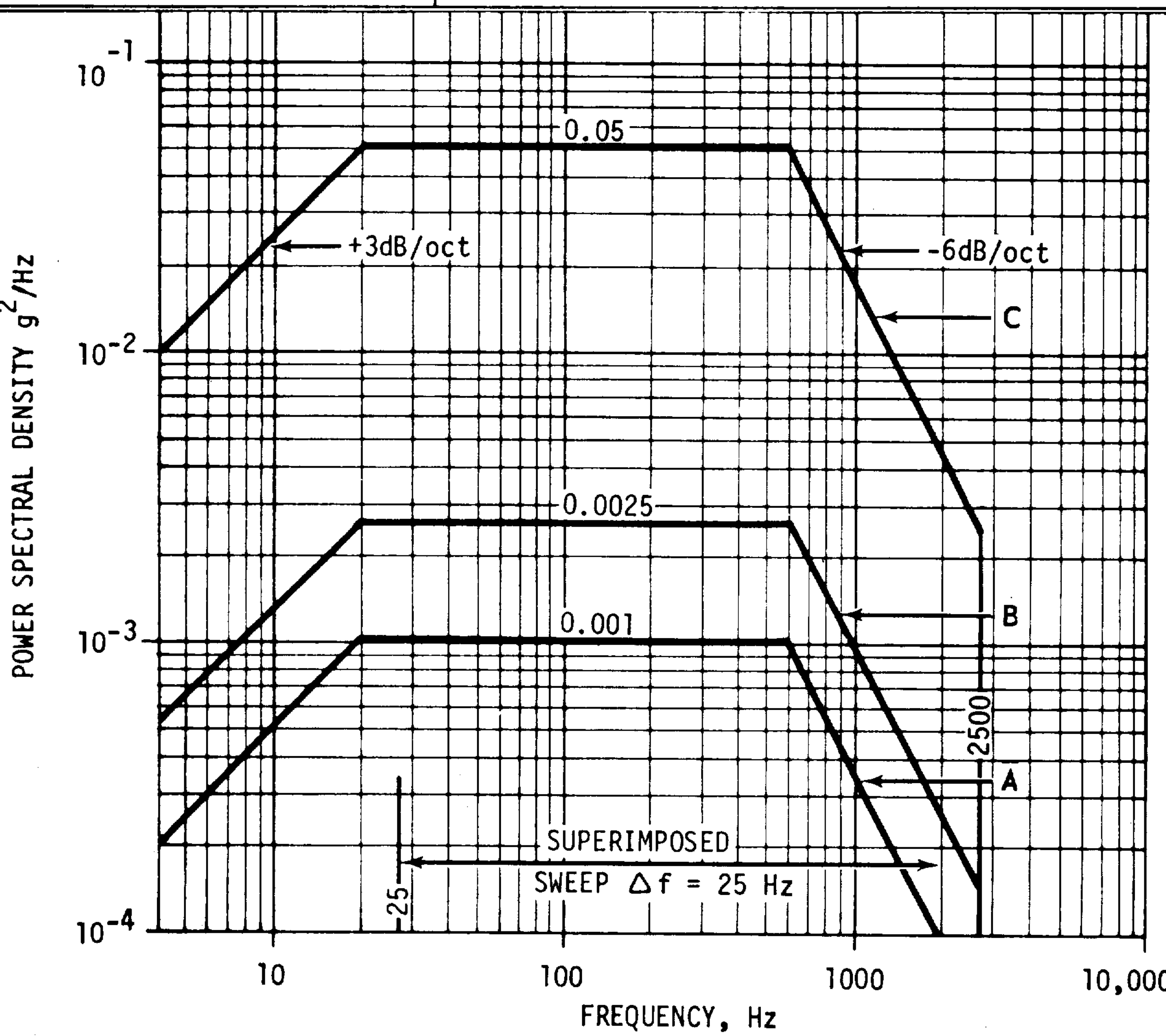
RANDOM VIBRATION ENVIRONMENT
ZONE 4.1.3
APS SERVICING PLATFORM
Z'-DIRECTION



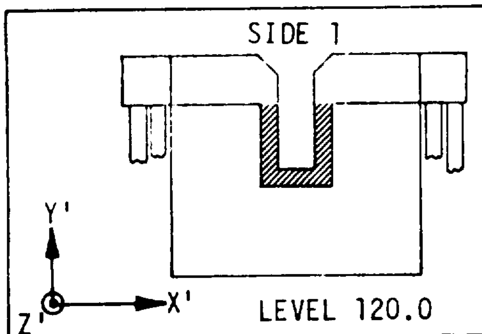
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.7
B	Lift-off Steady State Until Umbilical Disconnect	0.04	2.8
C	Lift-off Peak	0.2	11.5



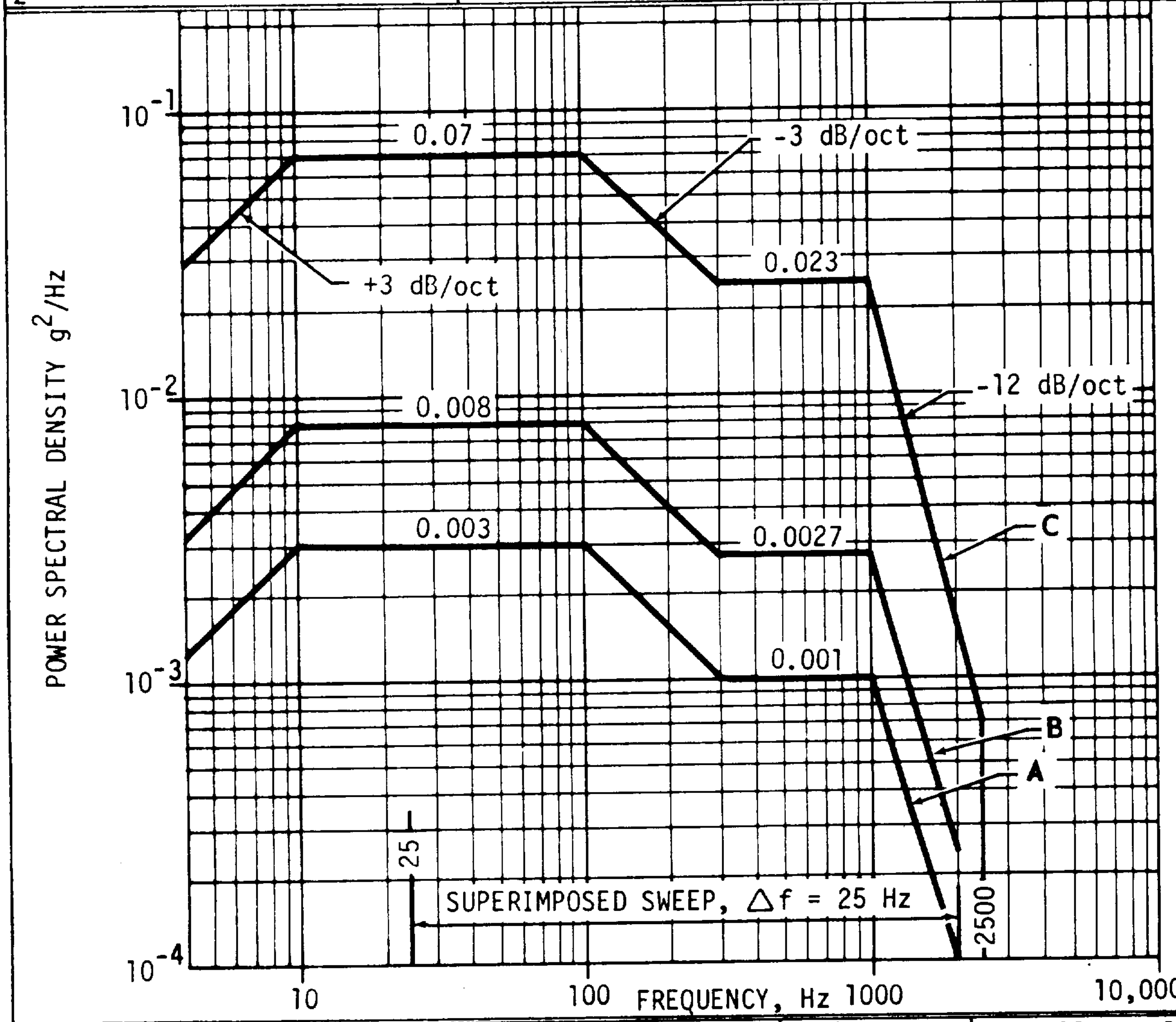
RANDOM VIBRATION ENVIRONMENT
ZONES 4.2.3.1 AND 4.2.3.2
INTERIOR WALKWAY AND HYPERGOL
ELECTRICAL EQUIPMENT PLATFORM
X' AND Y' DIRECTIONS



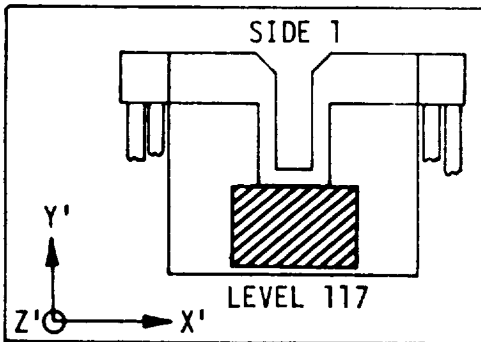
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.1
B	Lift-off Steady State Until Umbilical Disconnect	0.015	1.7
C	Lift-off Peak	0.15	7.5



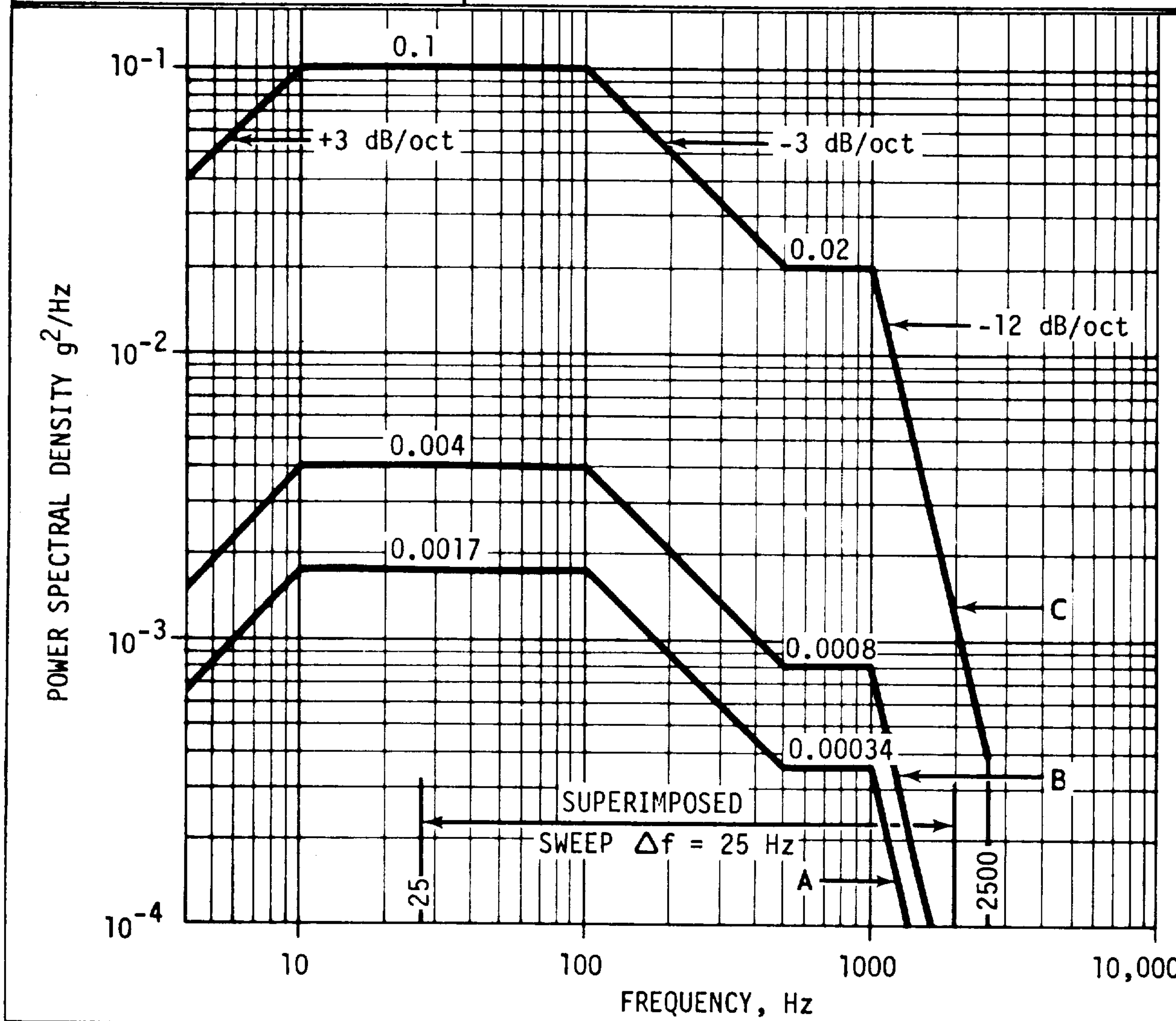
RANDOM VIBRATION ENVIRONMENT
ZONE 4.2.3.1
APU PLATFORM
INTERIOR WALKWAY AREA
Z'-DIRECTION



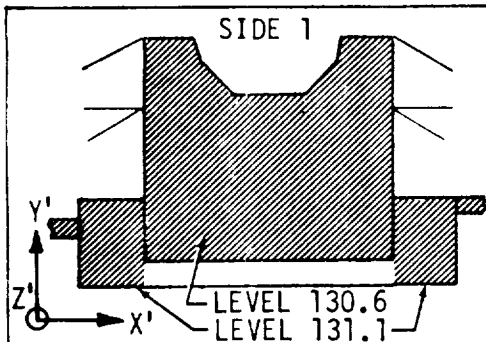
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.5
B	Lift-off Steady State Until Umbilical Disconnect	0.04	2.3
C	Lift-off Peak	0.15	6.4



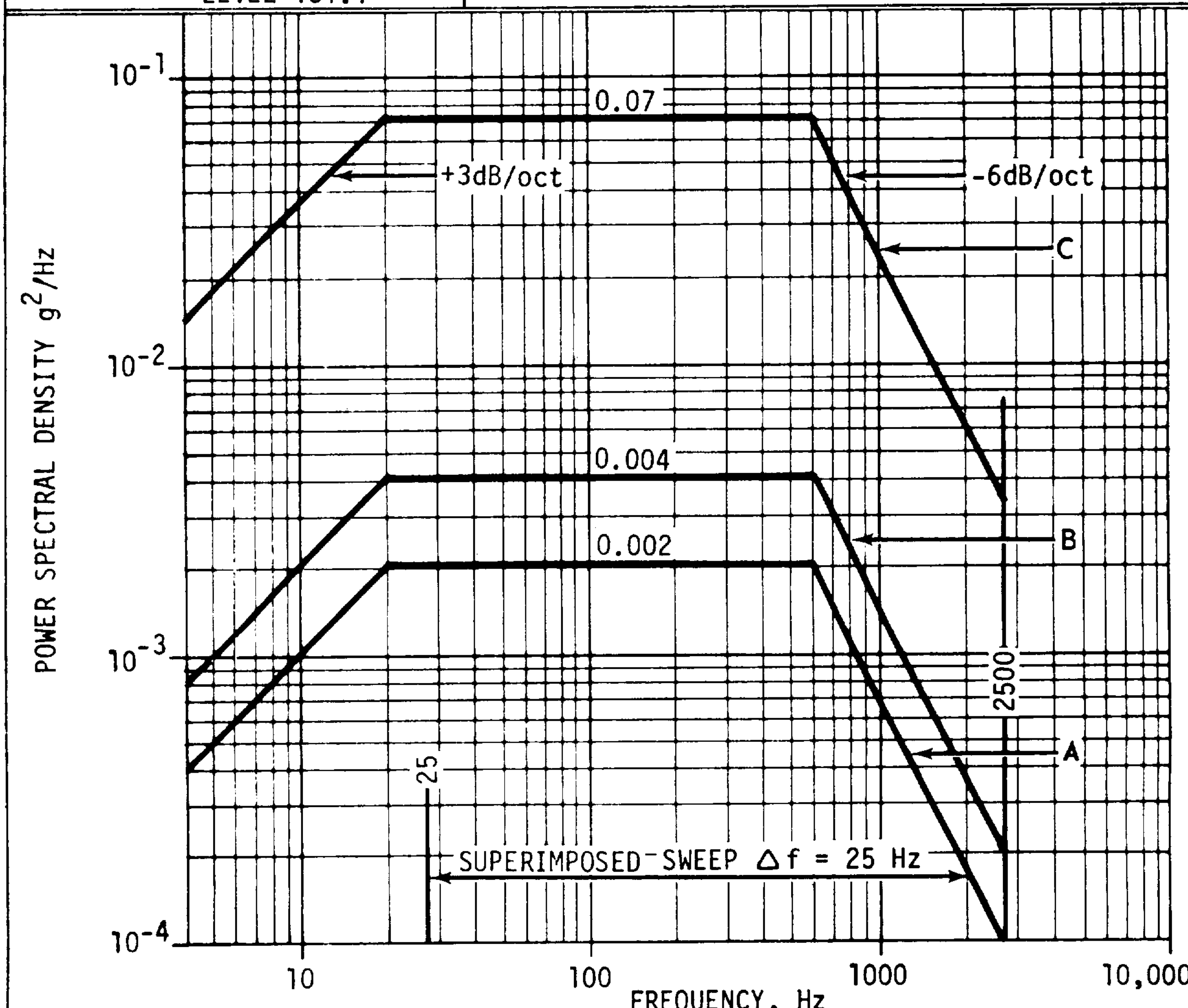
RANDOM VIBRATION ENVIRONMENT
ZONE 4.2.3.2
HYPERGOL ELECTRICAL EQUIPMENT PLATFORM
Z' DIRECTION



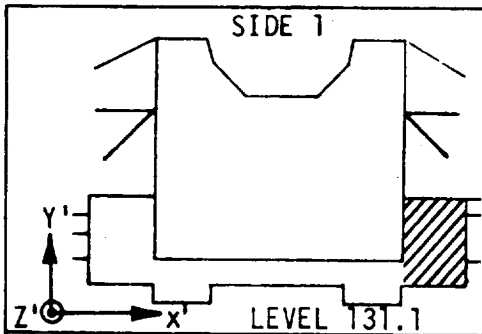
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.0
B	Lift-off Steady State Until Umbilical Disconnect	0.015	1.4
C	Lift-off Peak	0.2	6.8



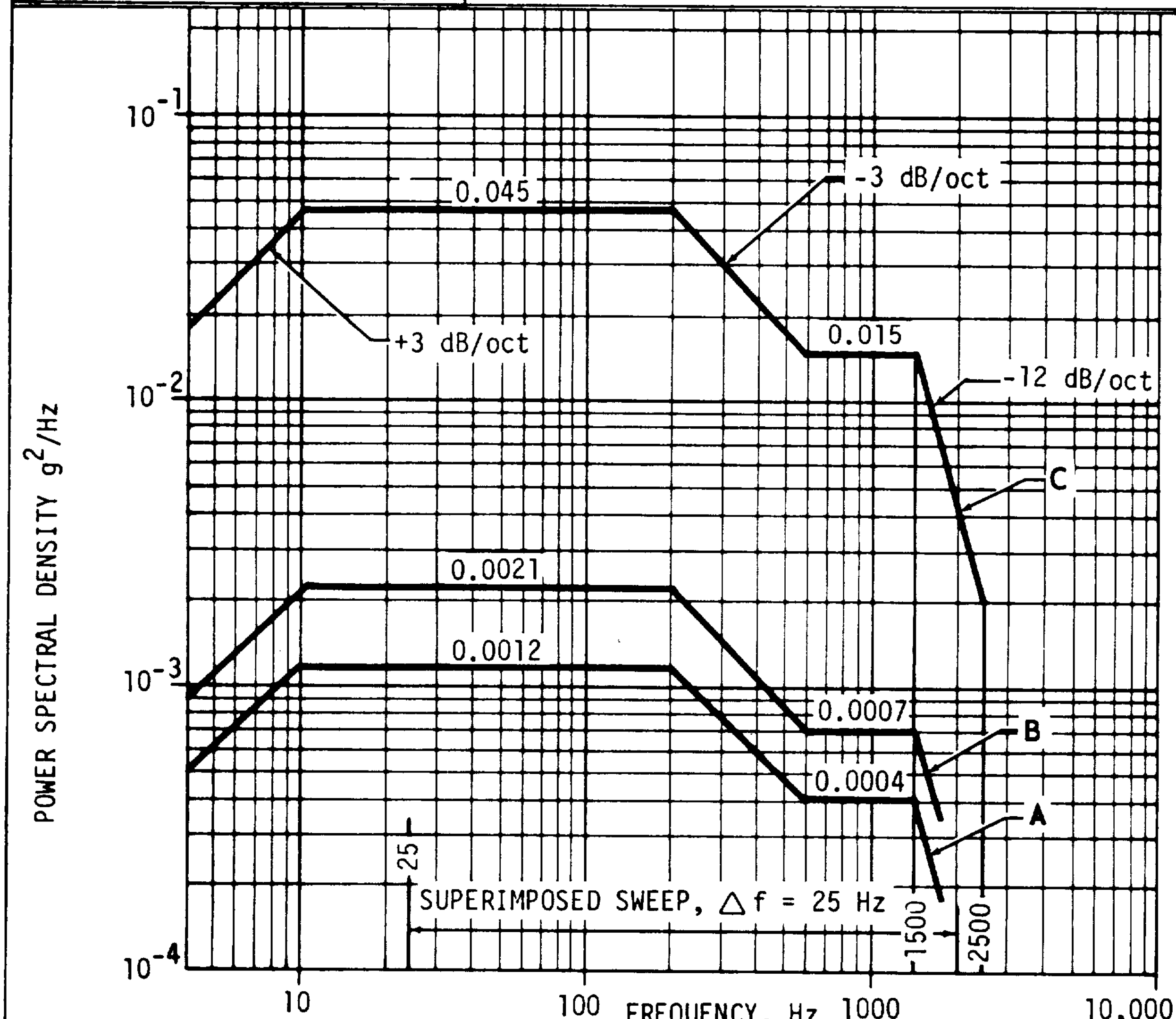
RANDOM VIBRATION ENVIRONMENT
ZONES 4.3.1, 4.3.2, AND 4.3.3
PCR MAIN FLOOR AND ADJACENT OUTSIDE PLATFORMS
X' AND Y' DIRECTIONS



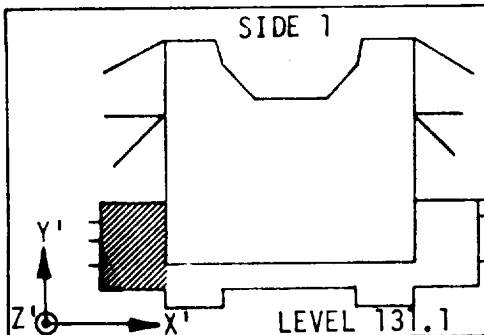
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.5
B	Lift-off Steady State Until Umbilical Disconnect	0.02	2.2
C	Lift-off Peak	0.2	8.8



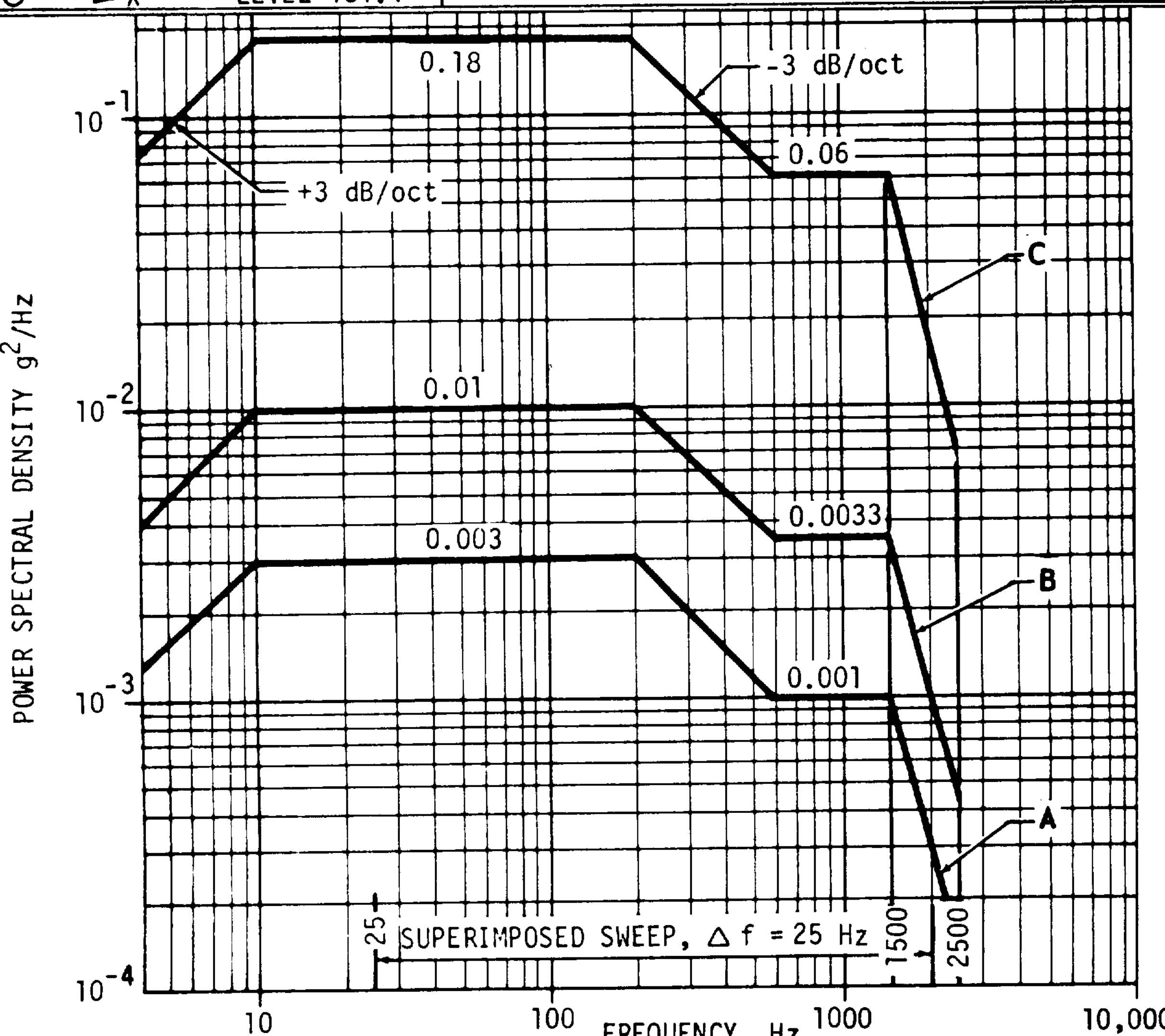
RANDOM VIBRATION ENVIRONMENT
ZONE 4.3.1
OUTSIDE PLATFORM ON SIDE 2 OF PCR
Z'-DIRECTION



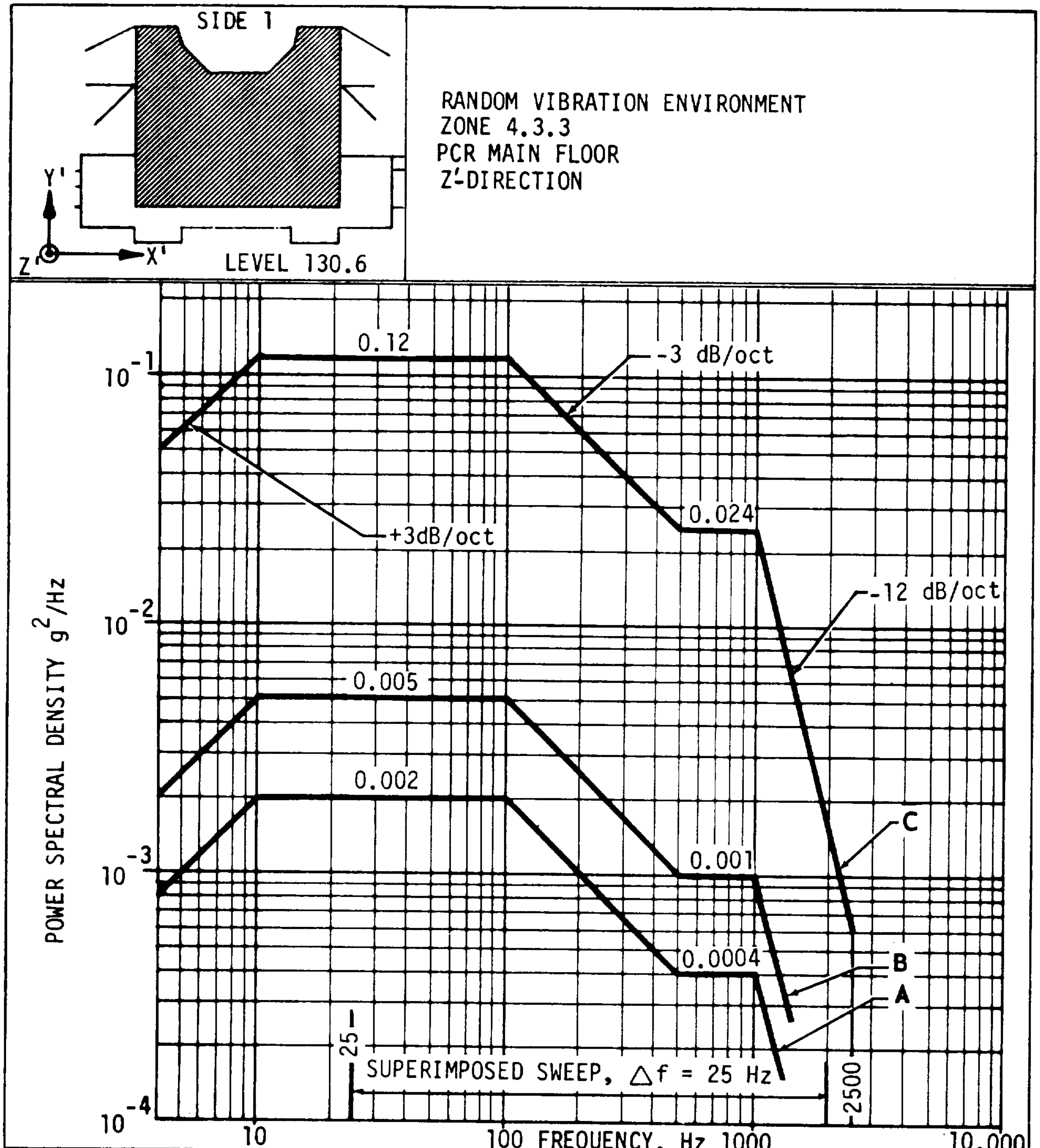
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.1
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.5
C	Lift-off Peak	0.1	6.4



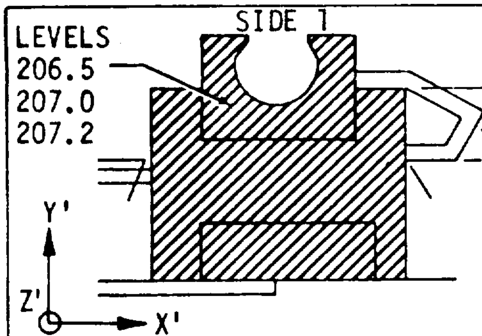
RANDOM VIBRATION ENVIRONMENT
ZONE 4.3.2
OUTSIDE PLATFORM ON SIDE 4 OF PCR
Z'-DIRECTION



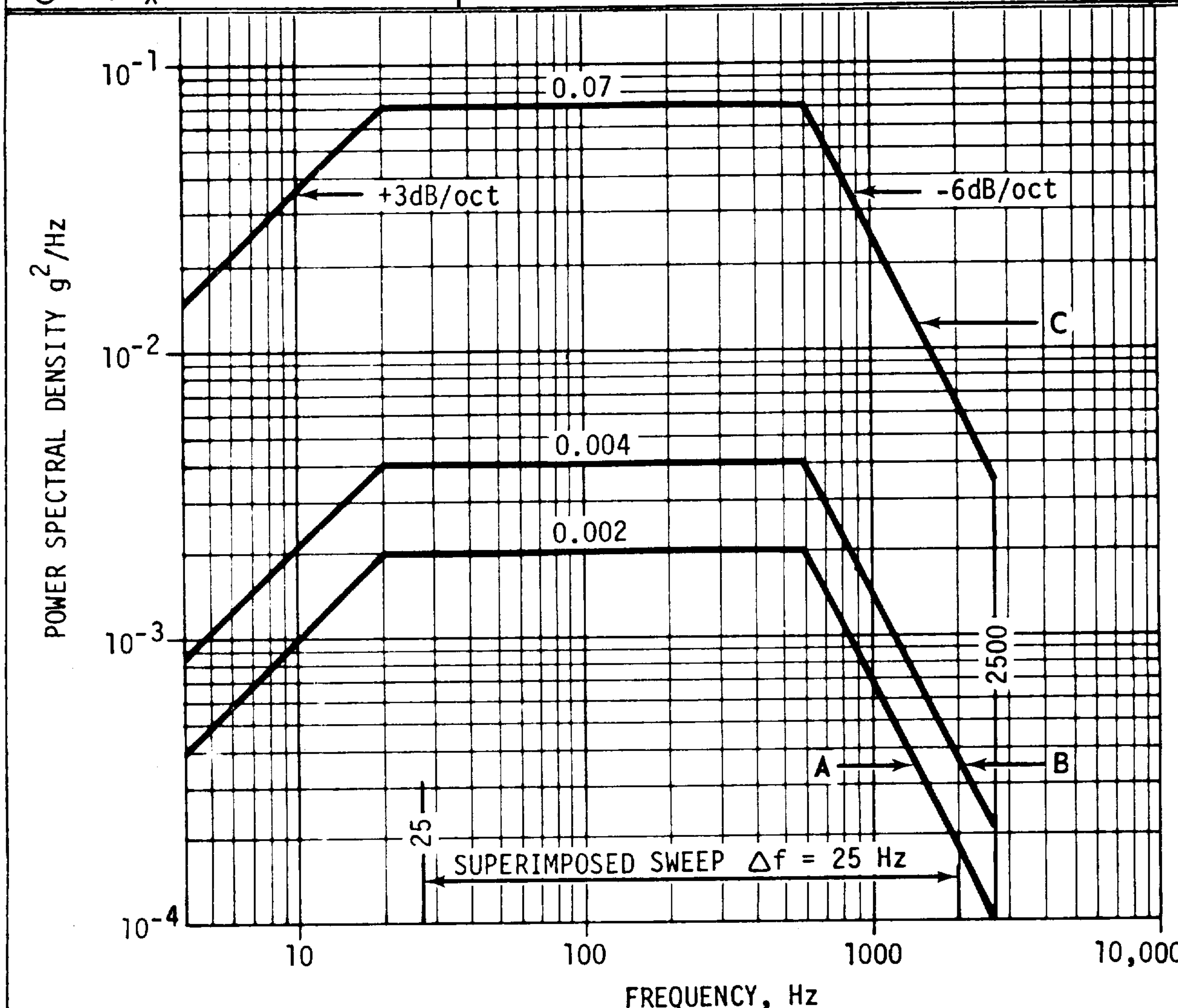
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.7
B	Lift-off Steady State Until Umbilical Disconnect	0.04	3.1
C	Lift-off Peak	0.3	12.6



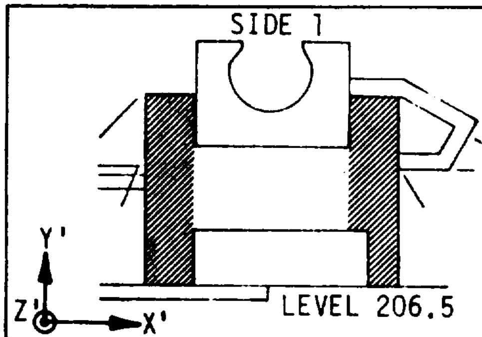
Sym	Launch Stage	Sweep △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.2
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.6
C	Lift-off Peak	0.2	7.4



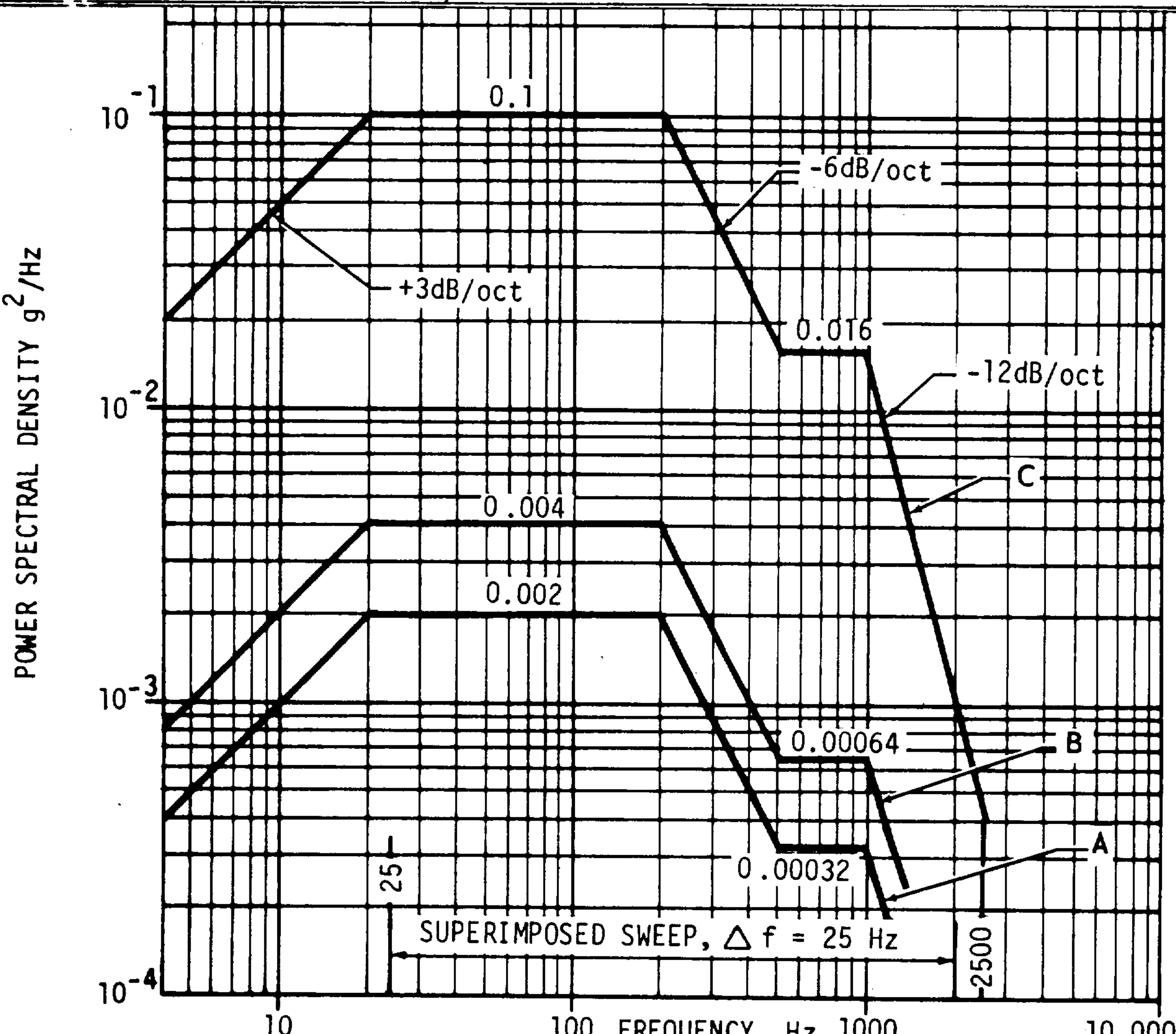
RANDOM VIBRATION ENVIRONMENT
ZONES 4.4.1, 4.4.2, AND 4.4.3
PCR ROOF, RCS ROOM FLOOR, AND HOIST
EQUIPMENT ROOM FLOOR
X' AND Y' DIRECTIONS



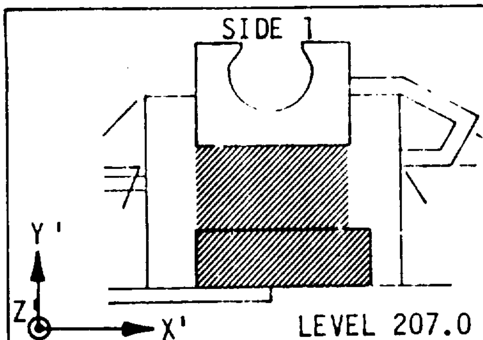
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.5
B	Lift-off Steady State Until Umbilical Disconnect	0.02	2.2
C	Lift-off Peak	0.2	8.8



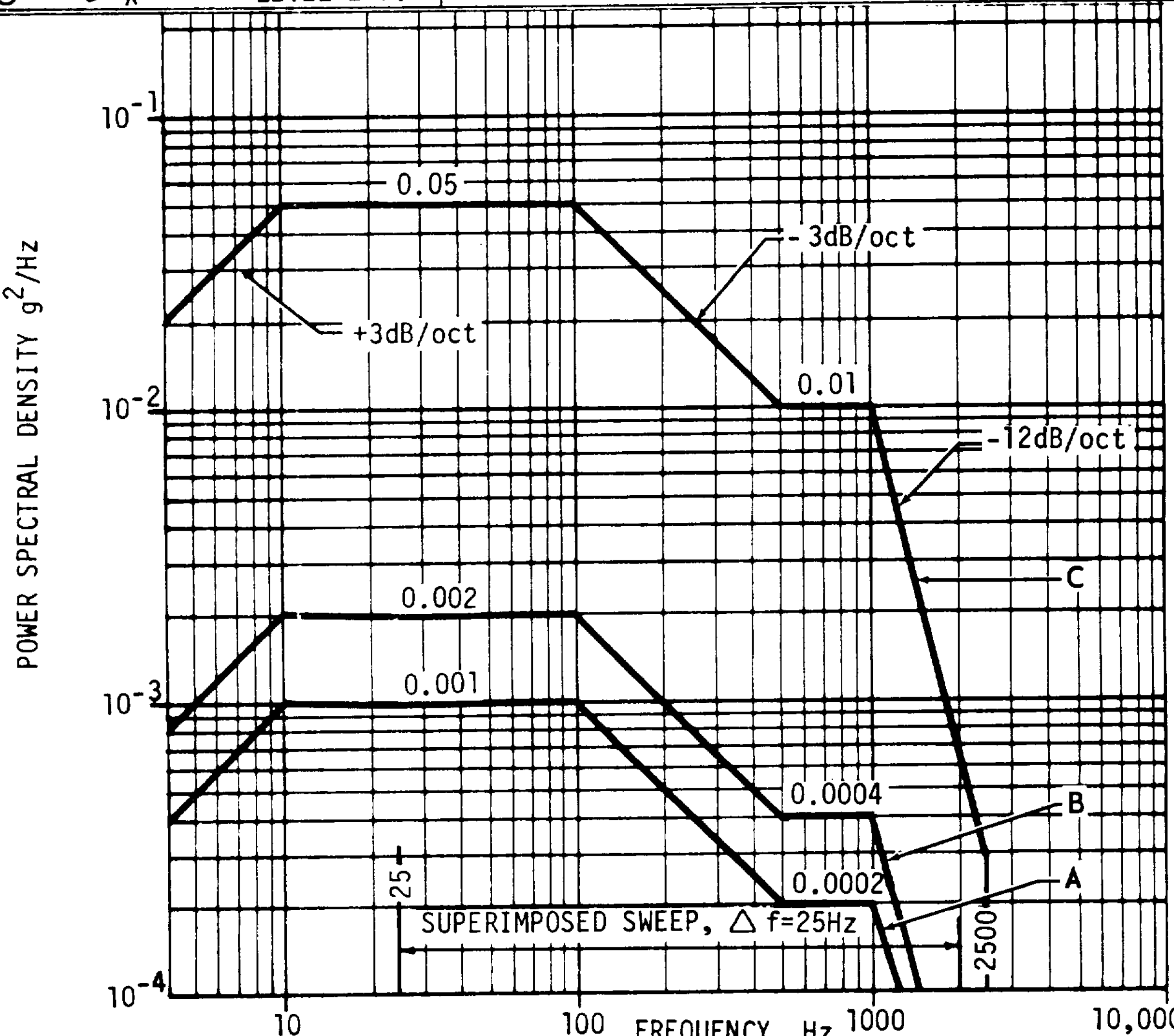
RANDOM VIBRATION ENVIRONMENT
ZONE 4.4.1
PCR ROOF PORTIONS NEAR
SIDES 2 AND 4
Z'-DIRECTION



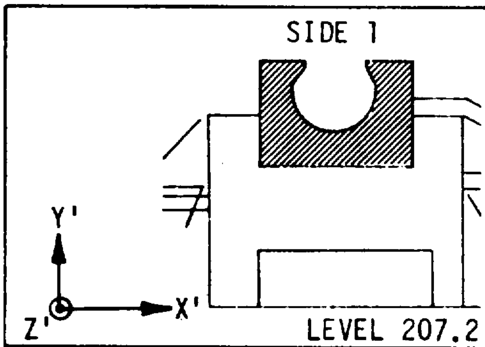
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.1
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.5
C	Lift-off Peak	0.3	7.2



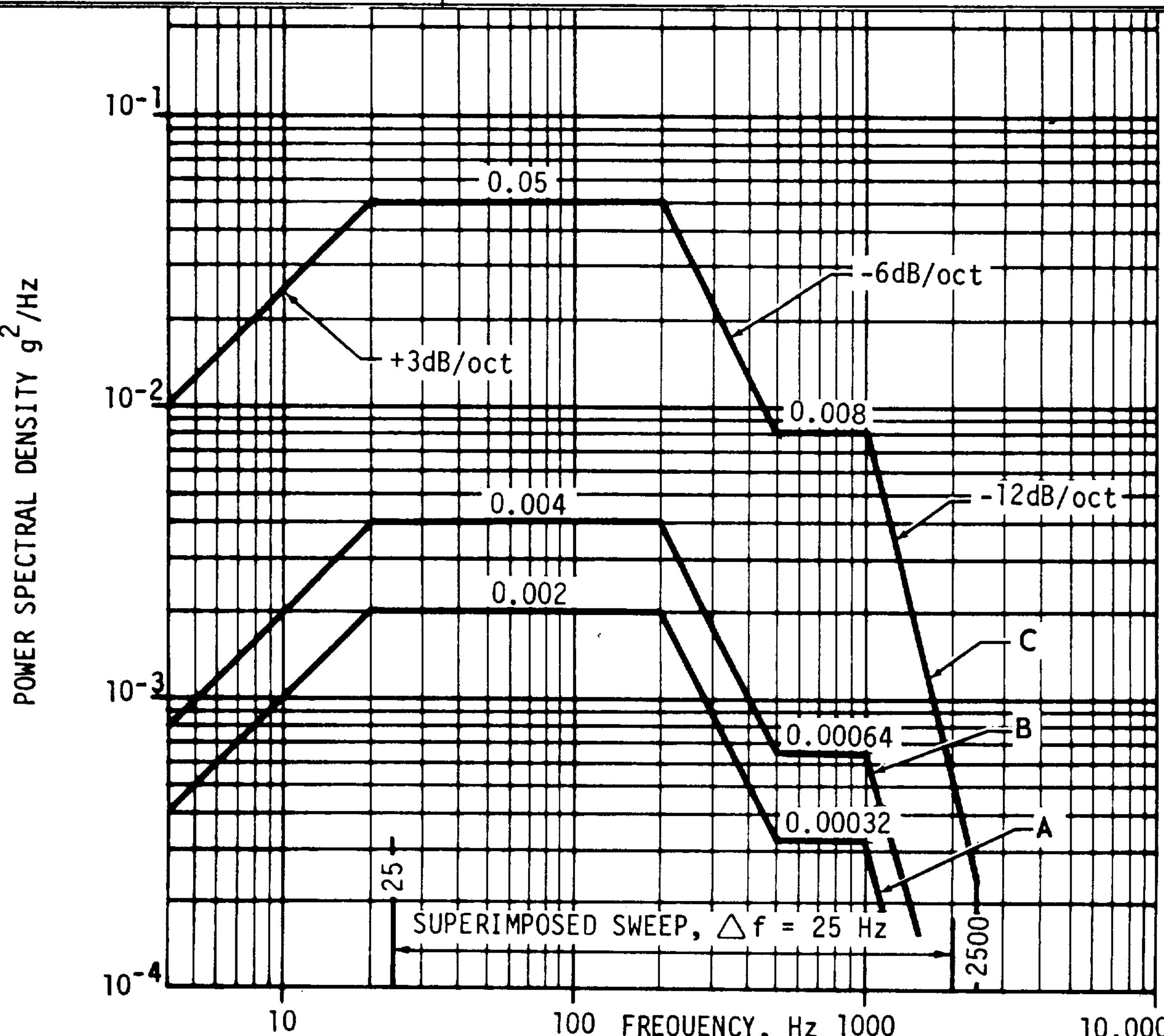
RANDOM VIBRATION ENVIRONMENT
ZONE 4.4.2
CENTRAL PORTION OF PCR ROOF
AND HOIST EQUIPMENT ROOM FLOOR
Z'-DIRECTION



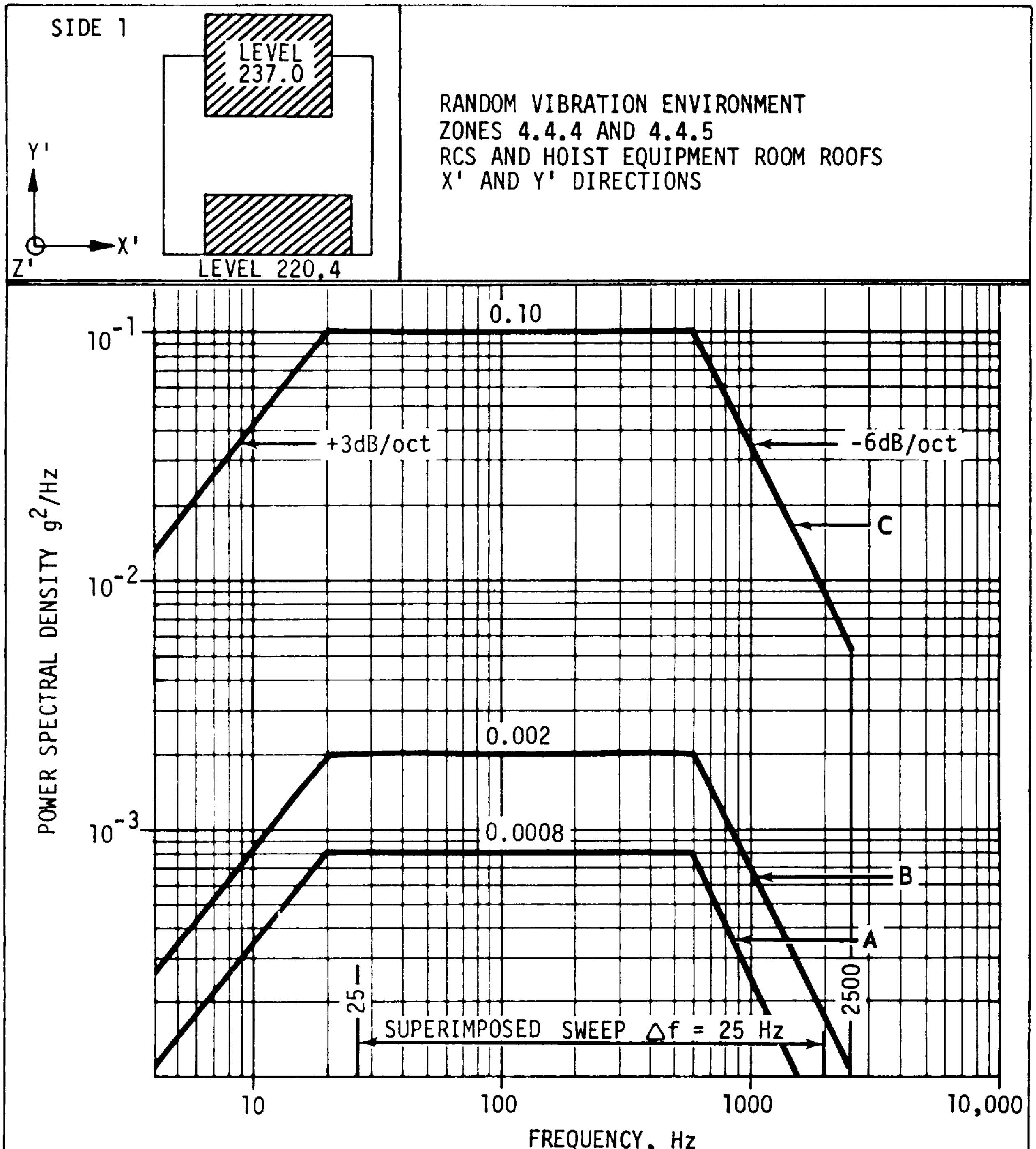
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	0.82
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.2
C	Lift-off Peak	0.2	5.1



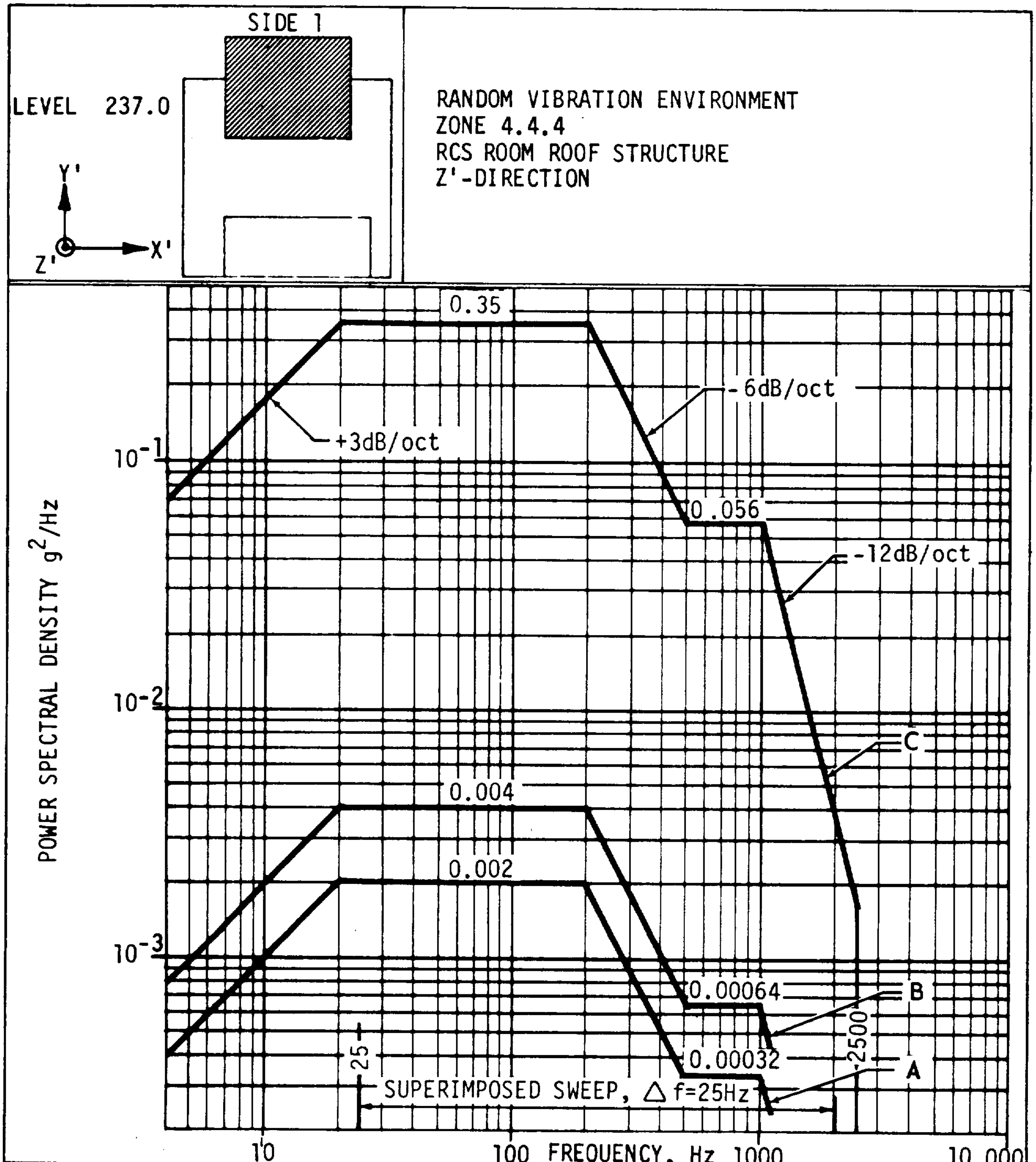
RANDOM VIBRATION ENVIRONMENT
ZONE 4.4.3
RCS ROOM FLOOR STRUCTURE
Z'-DIRECTION



Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.1
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.5
C	Lift-off Peak	0.2	5.2



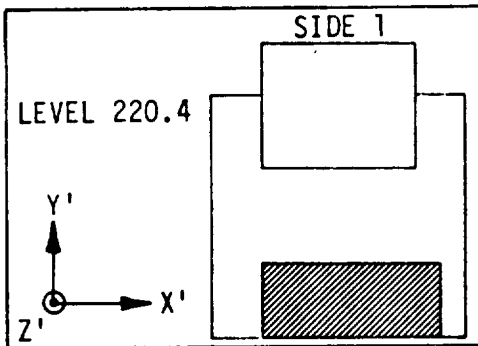
Sym	Launch Stage	Sweep, ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.0
B	Lift-off Steady State Until Umbilical Disconnect	0.01	1.5
C	Lift-off Peak	0.3	10.6

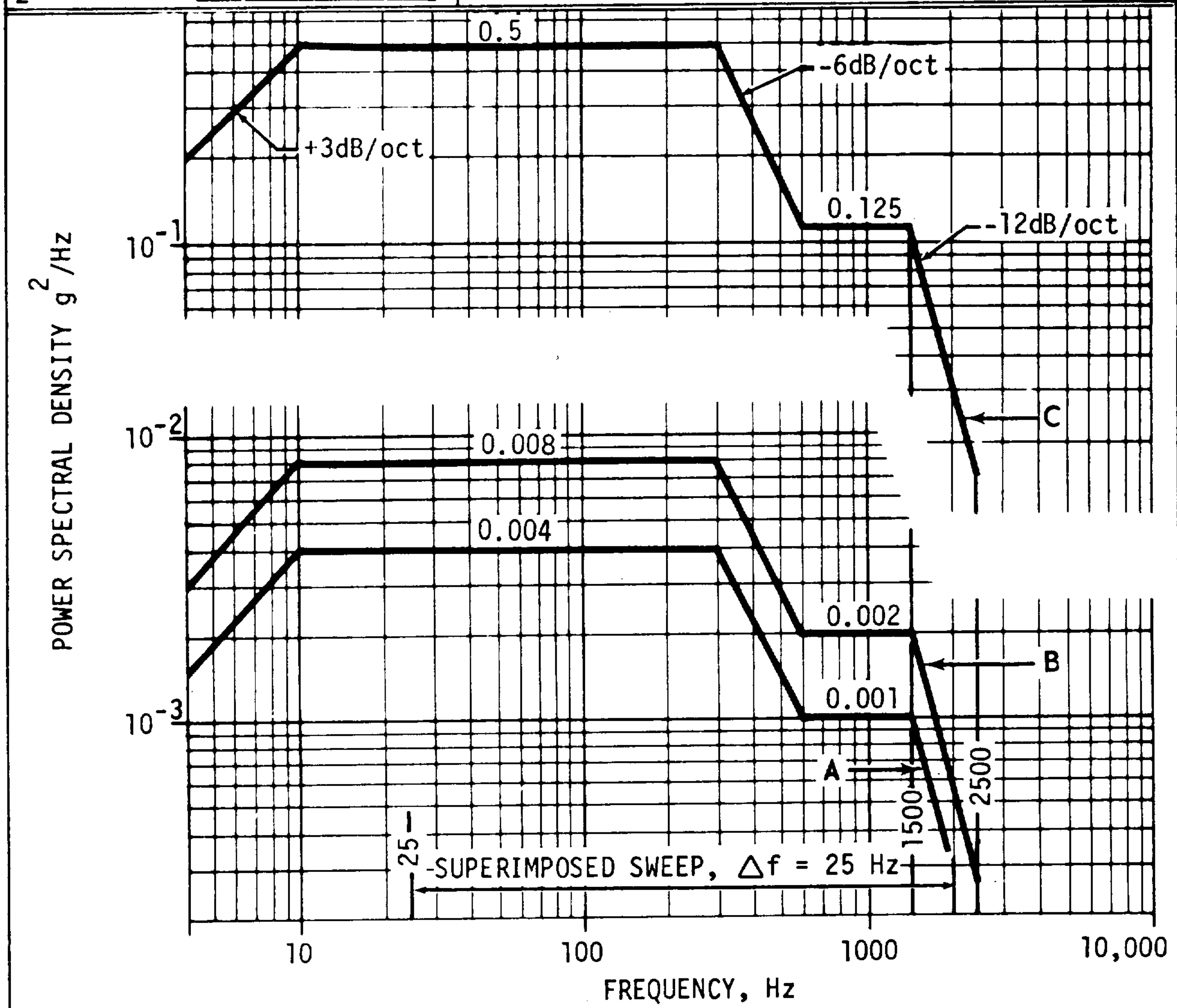


Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.1
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.5
C	Lift-off Peak	0.4	12.8

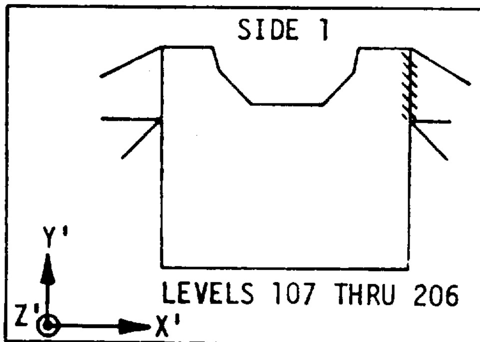
LEVEL 220.4

RANDOM VIBRATION ENVIRONMENT
ZONE 4.4.5
HOIST EQUIPMENT ROOM ROOF STRUCTURE
Z'-DIRECTION

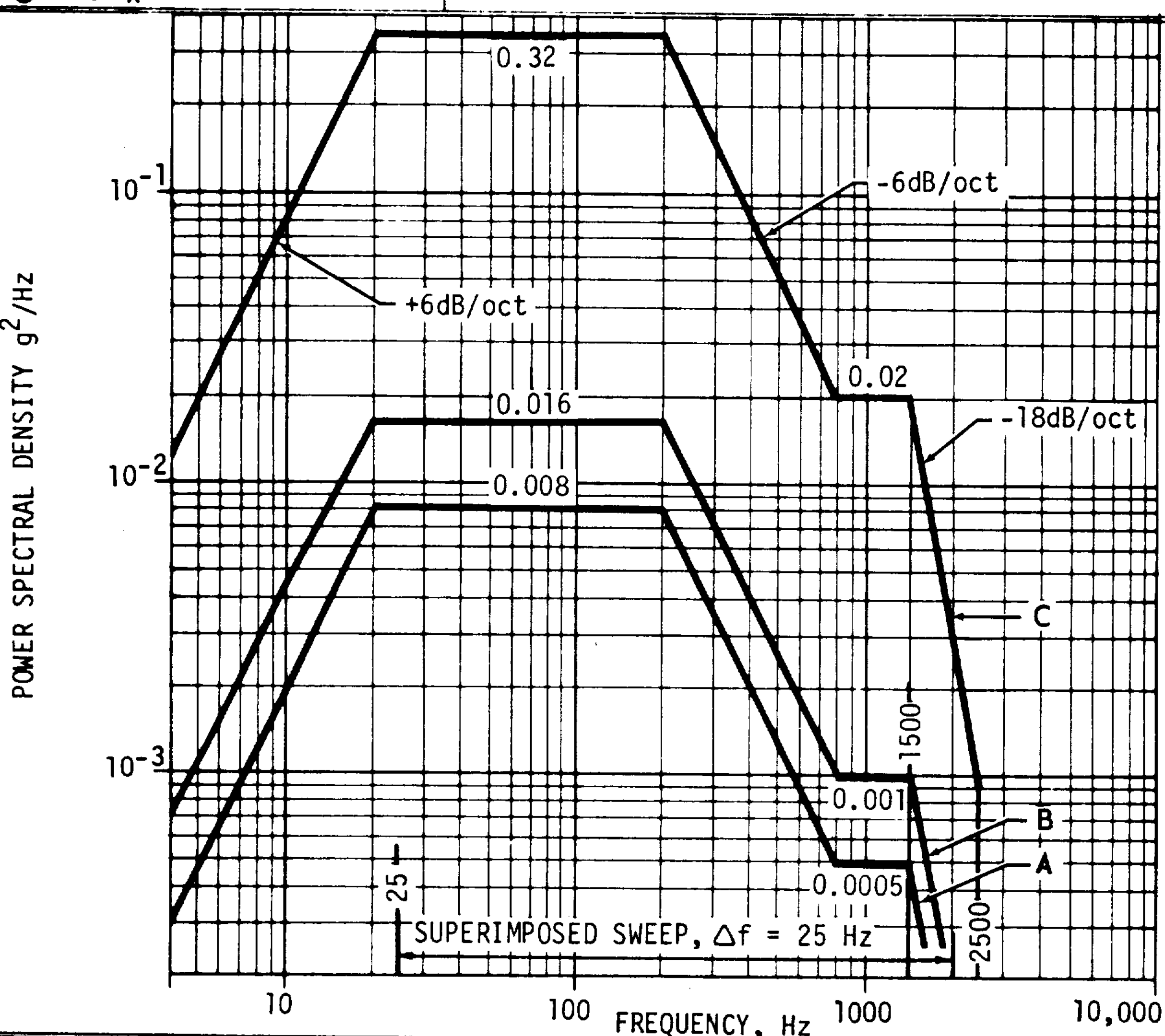




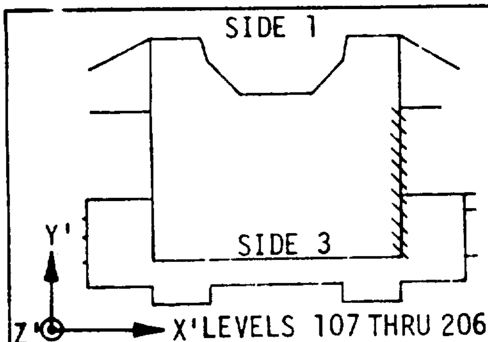
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.03	2.0
B	Lift-off Steady State Until Umbilical Disconnect	0.05	2.7
C	Lift-off Peak	0.9	20.1



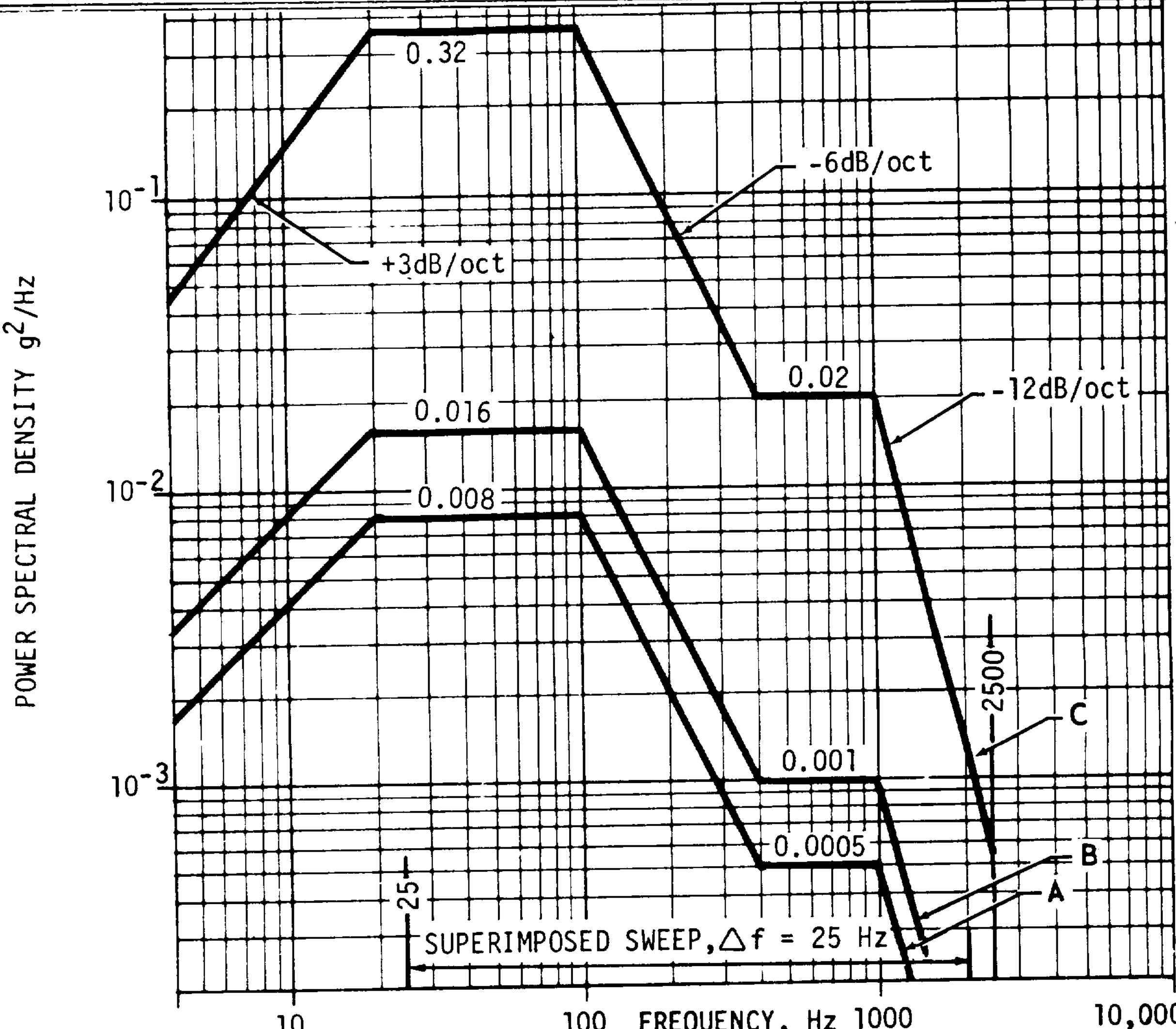
RANDOM VIBRATION ENVIRONMENT
ZONE 4.5.2
PCR WALL ON SIDE 2. AREA WITHIN 15 FT FROM SIDE 1, GIRT STRUCTURE X' DIRECTION



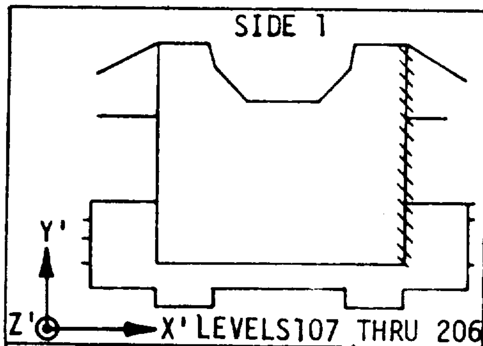
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.9
B	Lift-off Steady State Until Umbilical Disconnect	0.03	2.7
C	Lift-off Peak	0.6	11.9



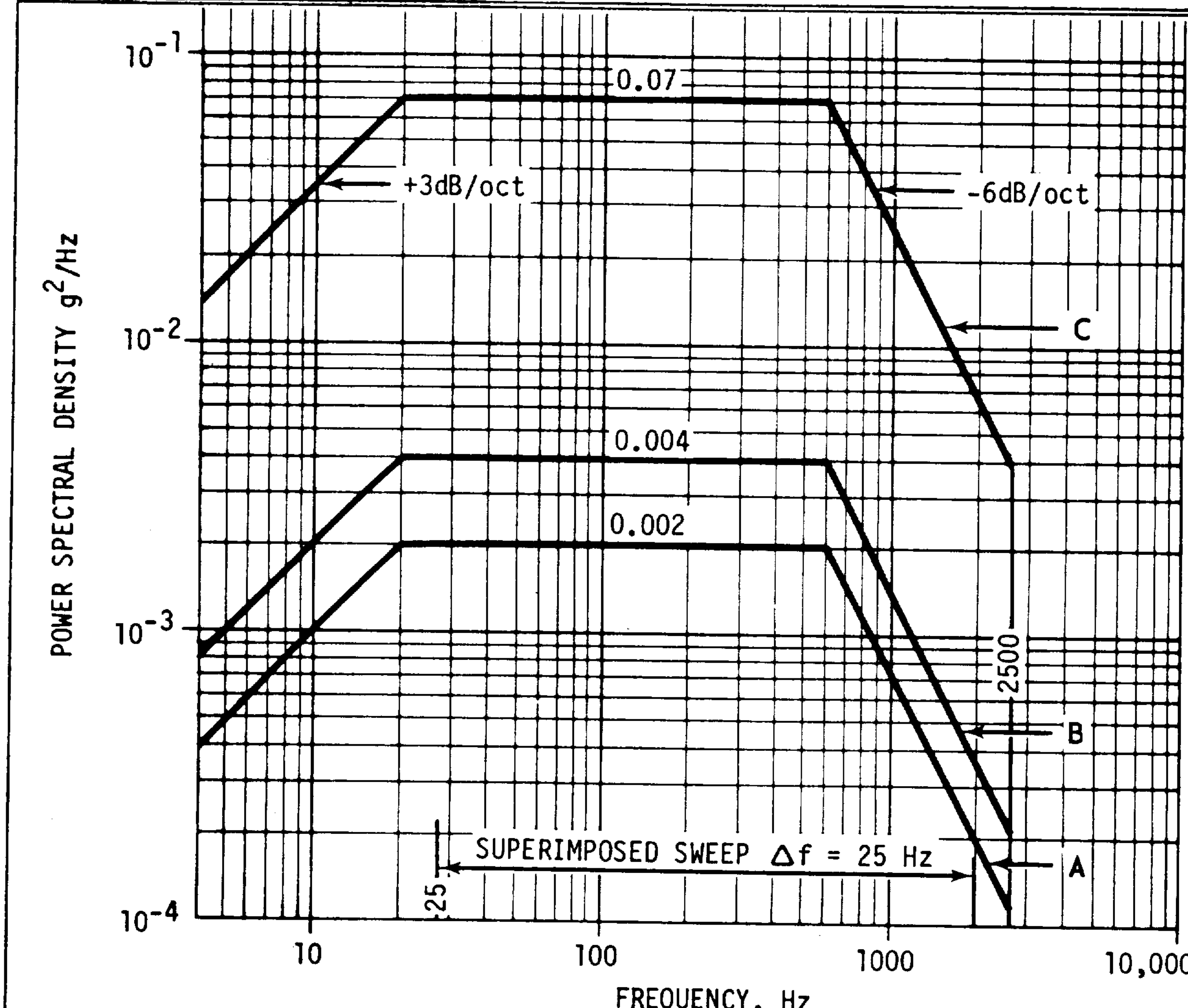
RANDOM VIBRATION ENVIRONMENT
ZONE 4.5.2.1
PCR WALL ON SIDE 2. AREA WITHIN 35 FT
FROM SIDE 3. GIRT STRUCTURE
X' DIRECTION



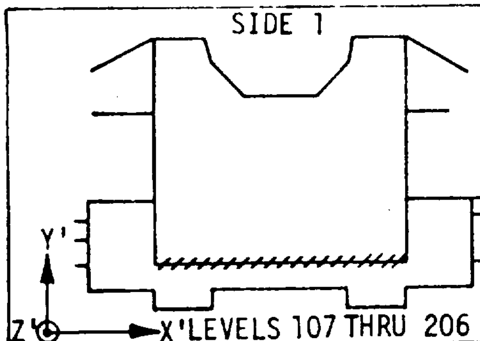
Sym	Launch Stage	Sweep, △PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.5
B	Lift-off Steady State Until Umbilical Disconnect	0.03	2.1
C	Lift-off Peak	0.4	9.0



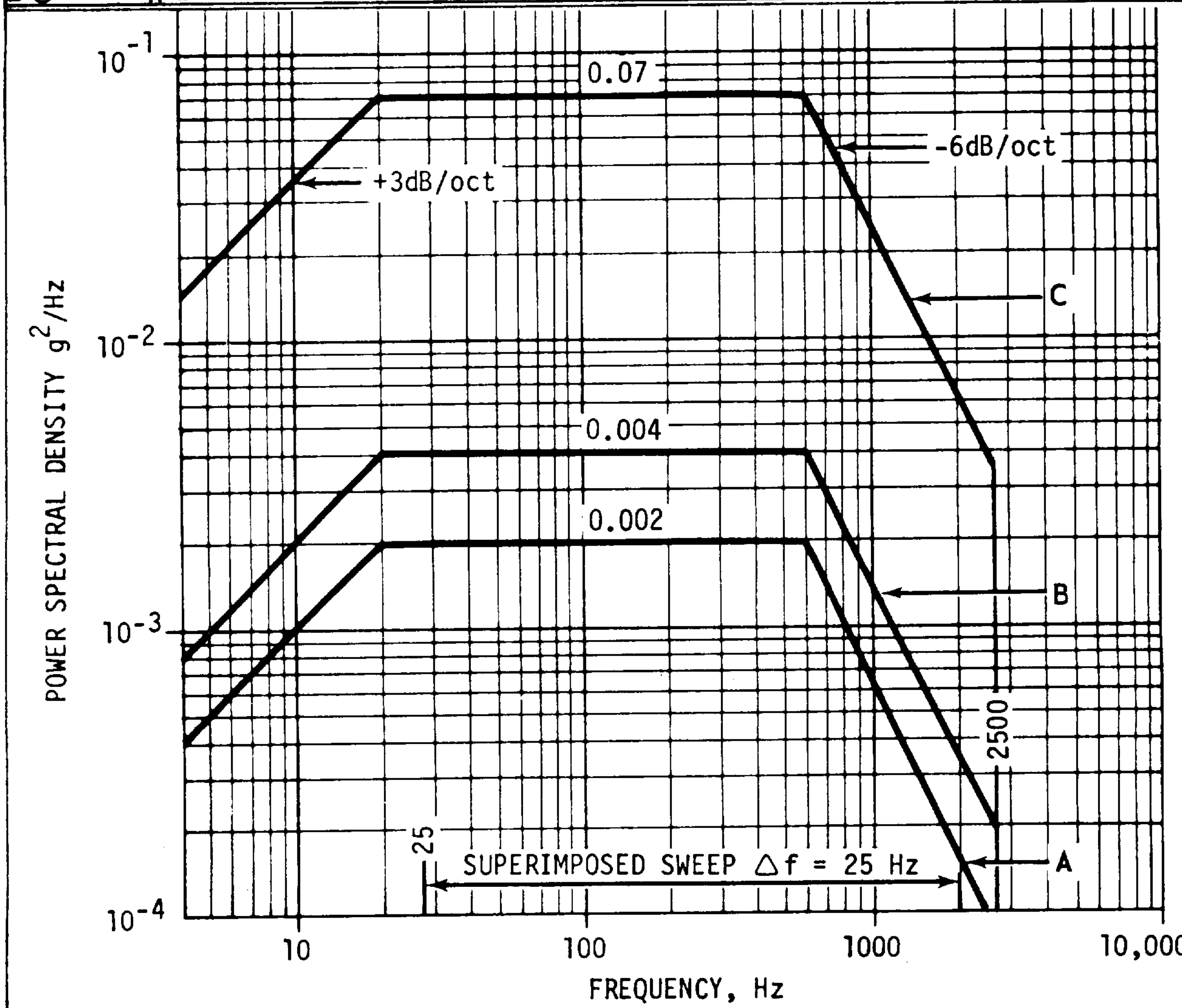
RANDOM VIBRATION ENVIRONMENT
ZONES 4.5.2 AND 4.5.2.1
PCR WALL ON SIDE 2.GIRT STRUCTURE
Y' AND Z' DIRECTIONS



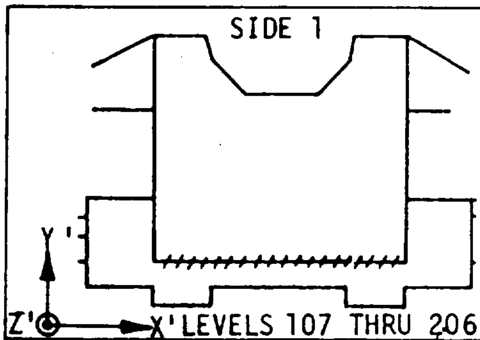
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.6
B	Lift-off Steady State Until Umbilical Disconnect	0.04	2.3
C	Lift-off Peak	0.2	8.8



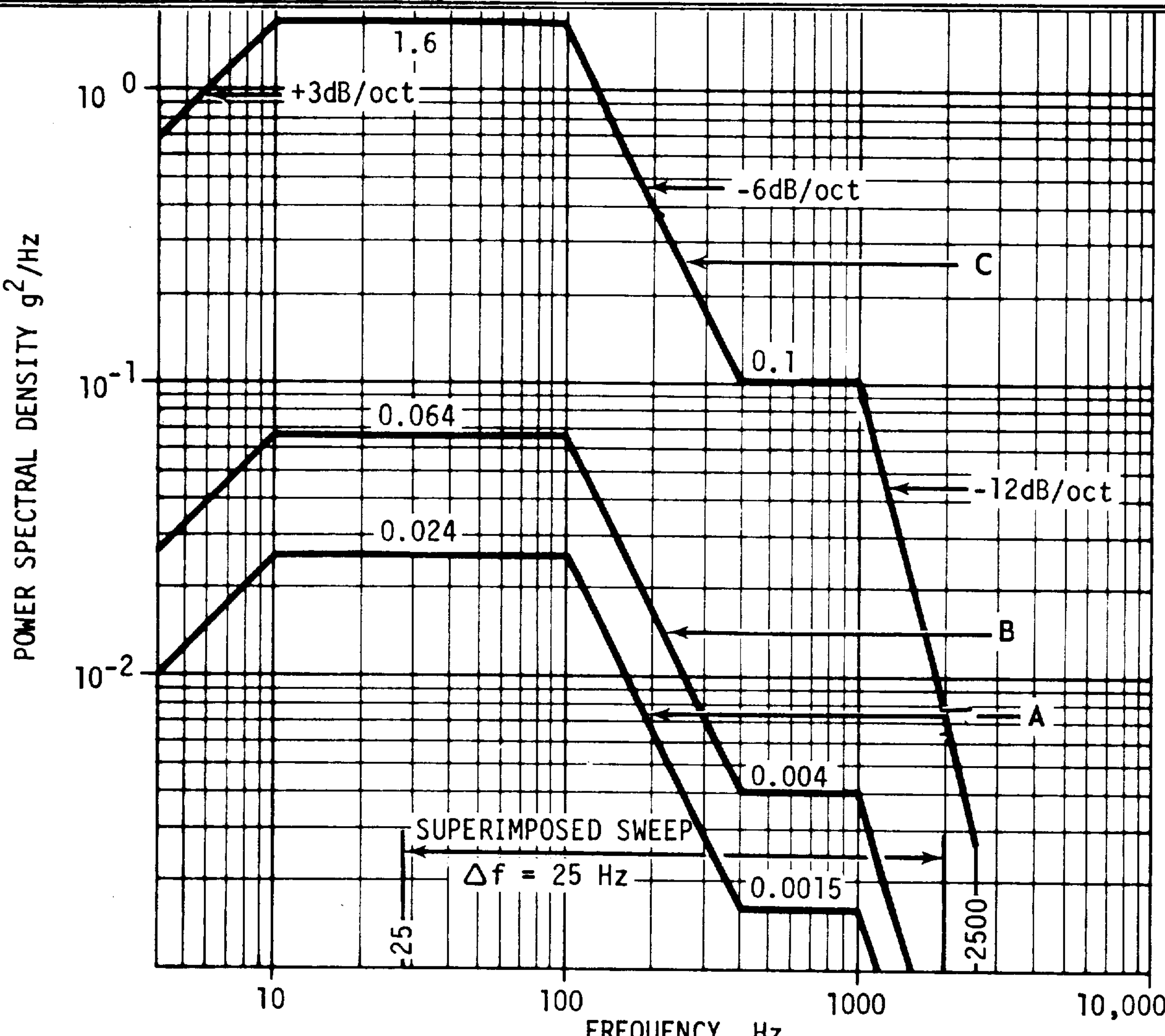
RANDOM VIBRATION ENVIRONMENT
ZONE 4.5.3
PCR WALL ON SIDE 3. GIRT STRUCTURE
X' AND Z' DIRECTIONS



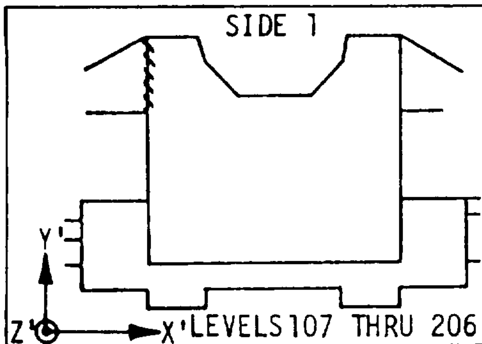
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.6
B	Lift-off Steady State Until Umbilical Disconnect	0.04	2.3
C	Lift-off Peak	0.2	8.8



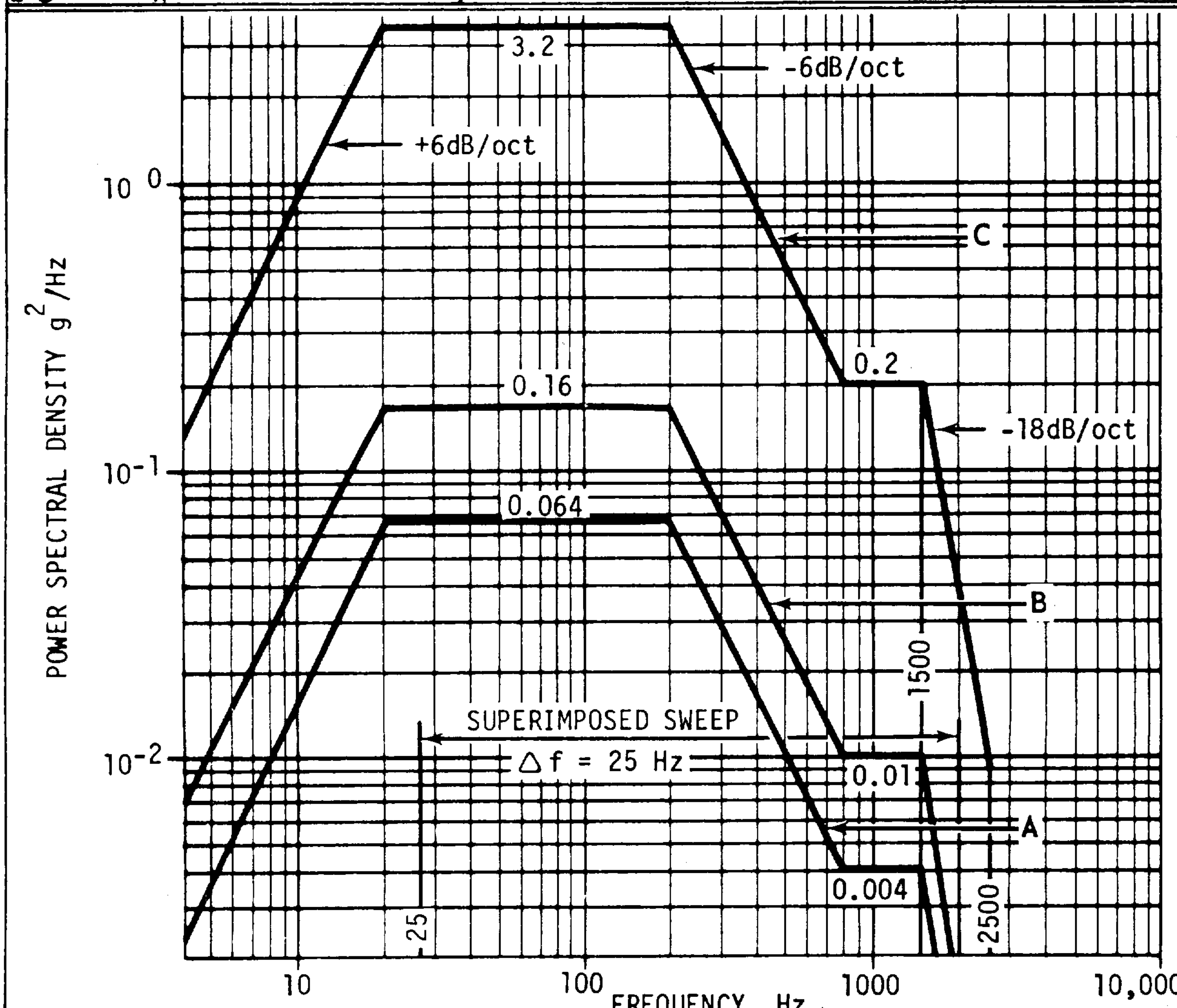
RANDOM VIBRATION ENVIRONMENT
ZONE 4.5.3
PCR WALL ON SIDE 3.GIRT STRUCTURE
Y' DIRECTION



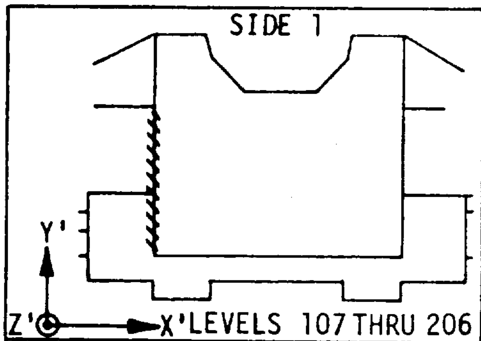
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	2.6
B	Lift-off Steady State Until Umbilical Disconnect	0.15	4.3
C	Lift-off Peak	3.0	20.9



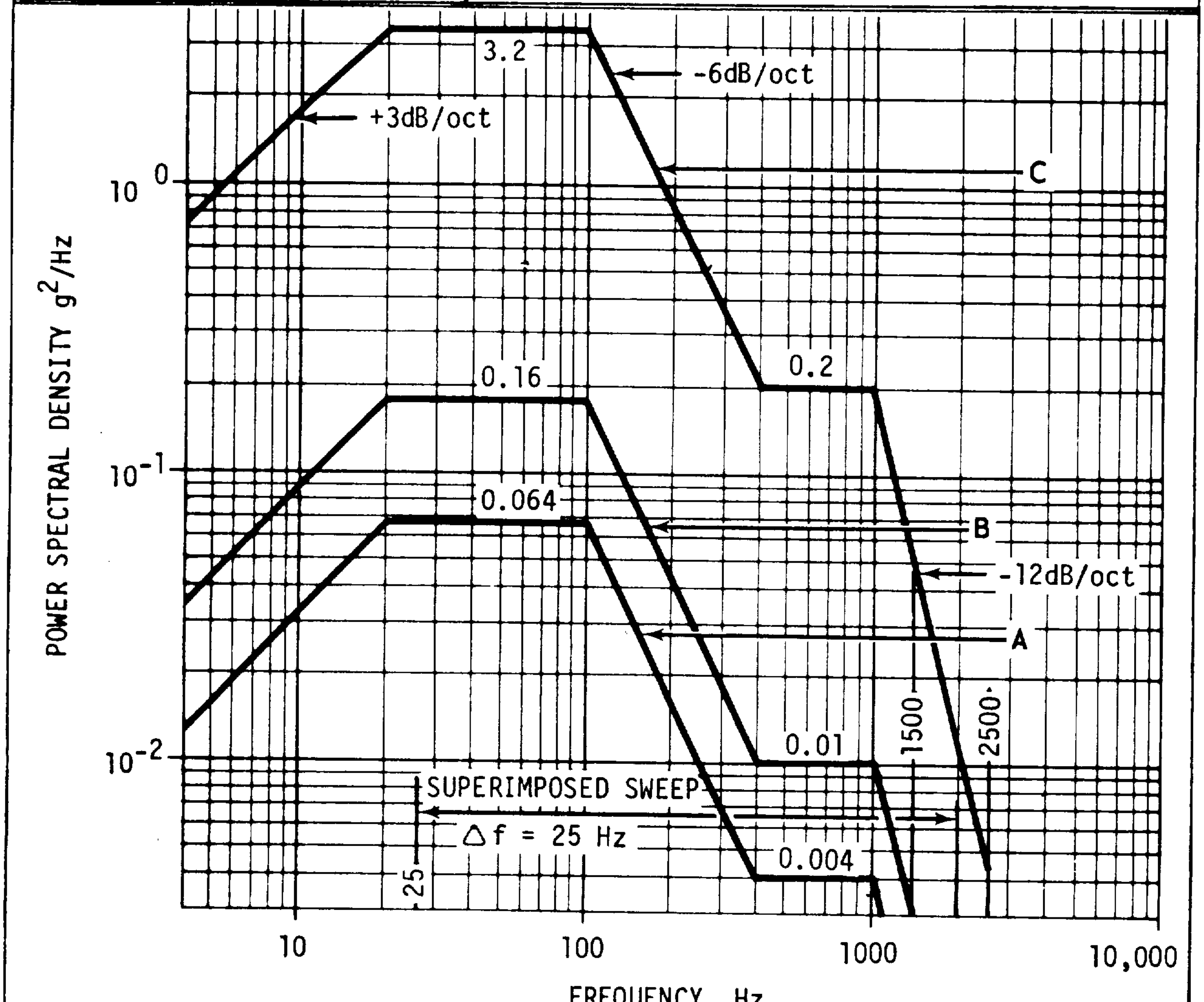
RANDOM VIBRATION ENVIRONMENT
ZONE 4.5.4
PCR WALL ON SIDE 4,
AREA WITHIN 15 FT FROM
SIDE 1. GIRT STRUCTURE
X' DIRECTION



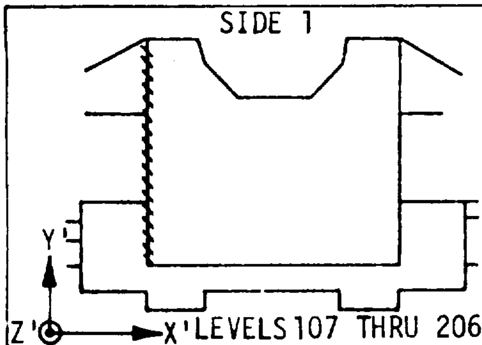
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	5.3
B	Lift-off Steady State Until Umbilical Disconnect	0.3	8.4
C	Lift-off Peak	6.0	37.7



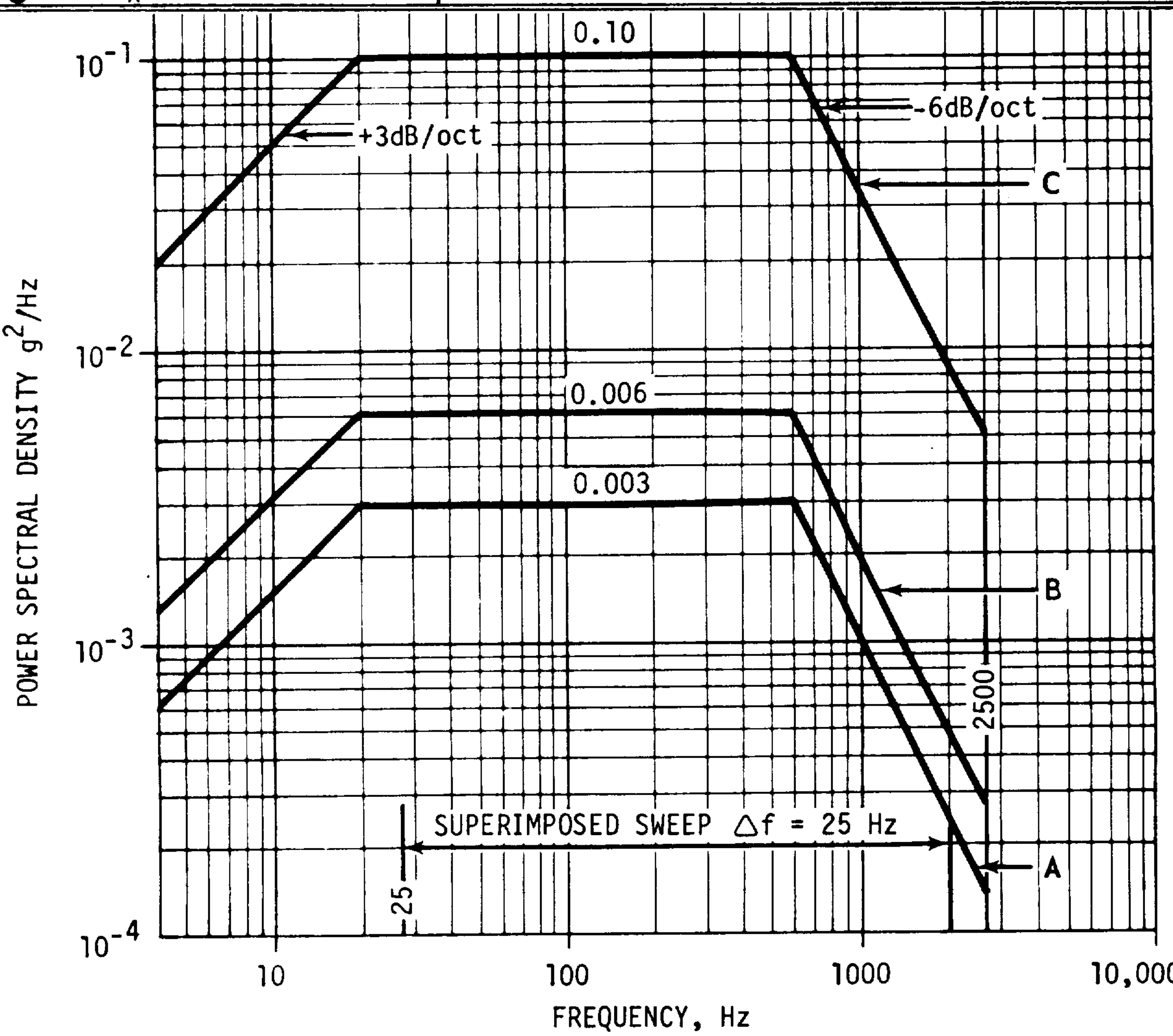
RANDOM VIBRATION ENVIRONMENT
ZONE 4.5.4.1
PCR WALL ON SIDE 4, AREA
WITHIN 35 FT FROM SIDE 3, GIRT STRUCTURE
X' DIRECTION



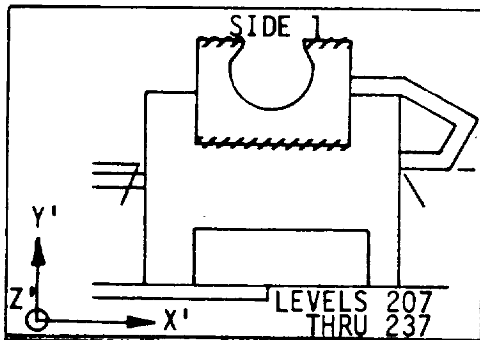
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.1	4.1
B	Lift-off Steady State Until Umbilical Disconnect	0.15	6.3
C	Lift-off Peak	3.0	28.0



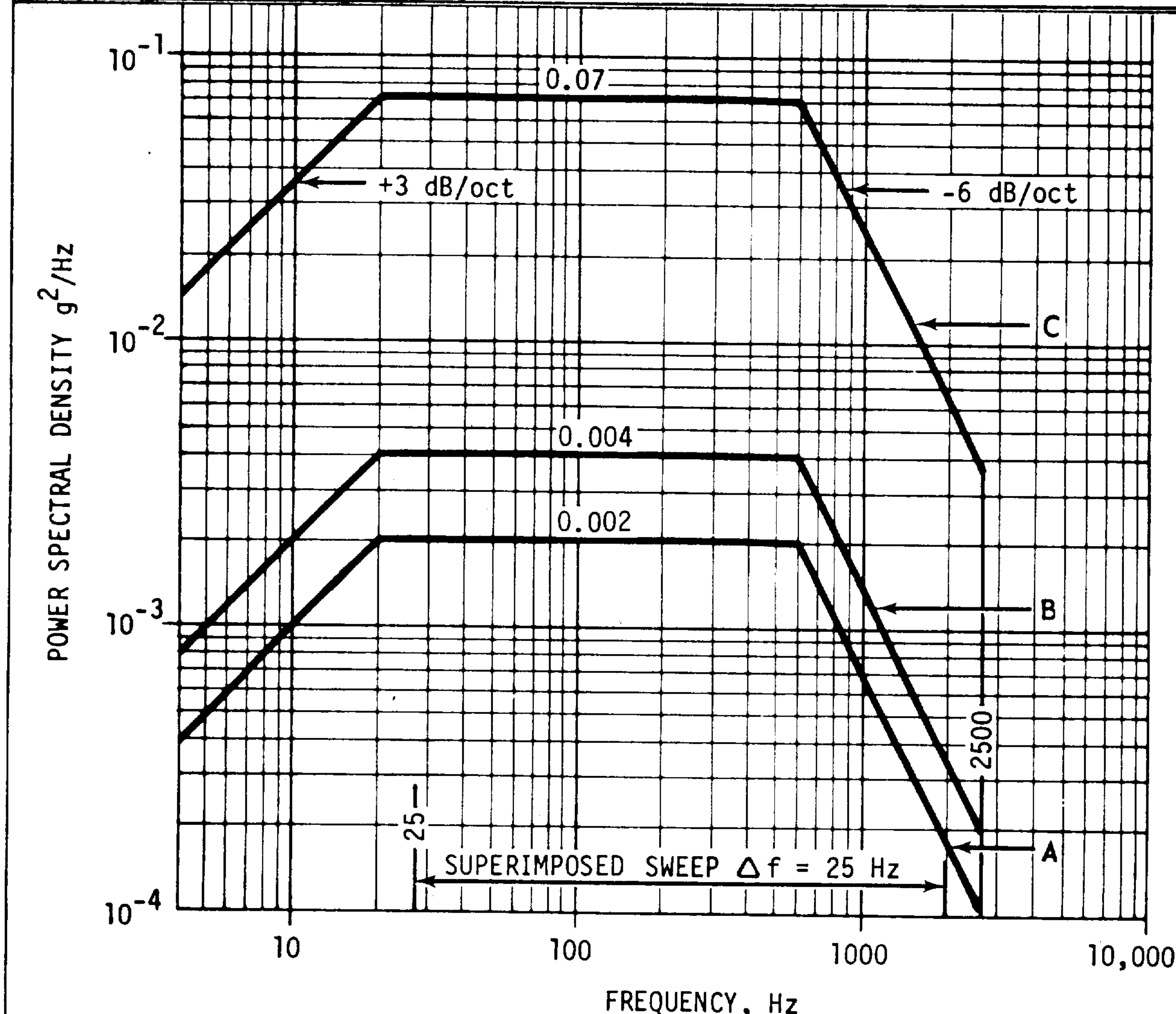
RANDOM VIBRATION ENVIRONMENT
ZONES 4.5.4 AND 4.5.4.1
PCR WALL ON SIDE 4, GIRT STRUCTURE
Y' AND Z' DIRECTIONS



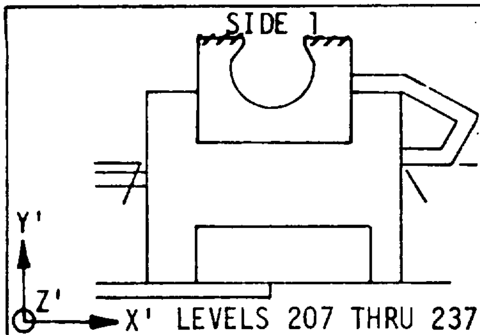
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.03	2.0
B	Lift-off Steady State Until Umbilical Disconnect	0.05	2.7
C	Lift-off Peak	0.3	10.6



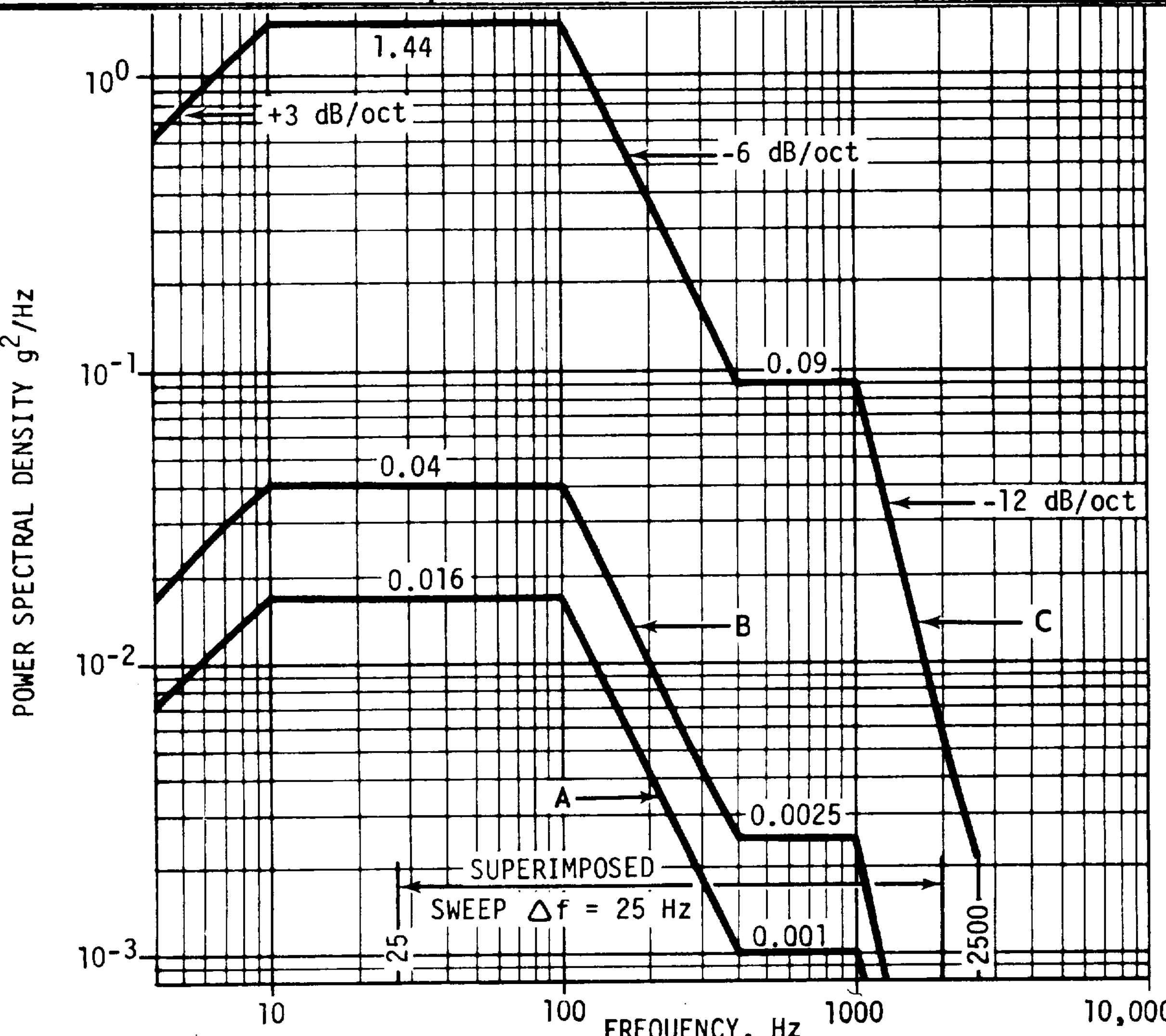
RANDOM VIBRATION ENVIRONMENT
ZONES 4.6.1 AND 4.6.3
RCS WALLS ON SIDE 1 and 3. GIRT STRUCTURE
X' DIRECTION



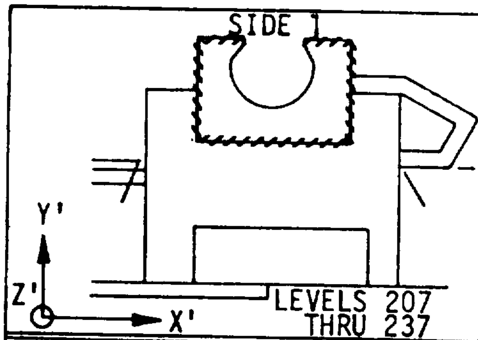
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.6
B	Lift-off Steady State Until Umbilical Disconnect	0.04	2.3
C	Lift-off Peak	0.2	8.8



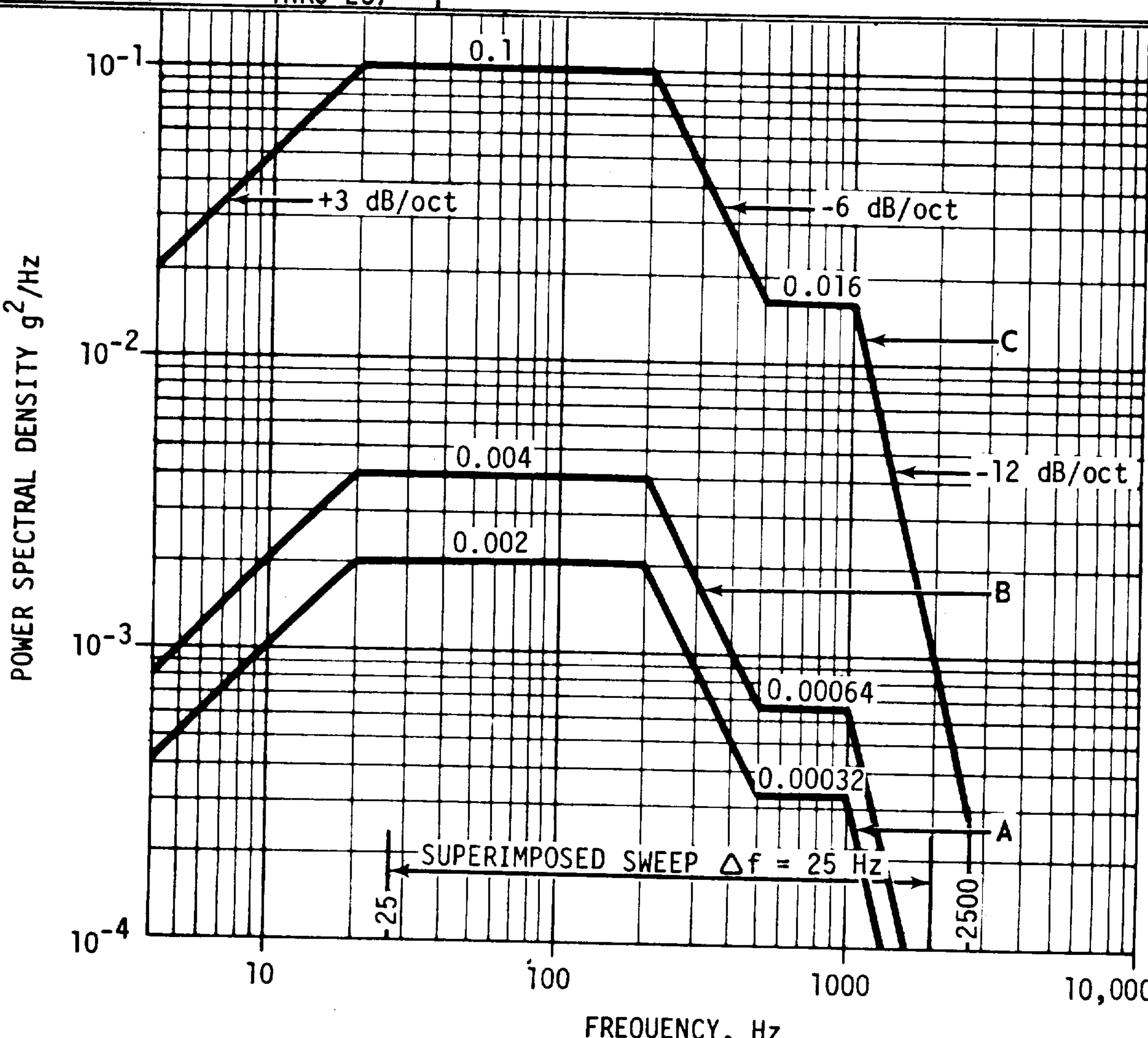
RANDOM VIBRATION ENVIRONMENT
ZONE 4.6.1
RCS ROOM WALL ON SIDE 1.
GIRT STRUCTURE
Y' DIRECTION



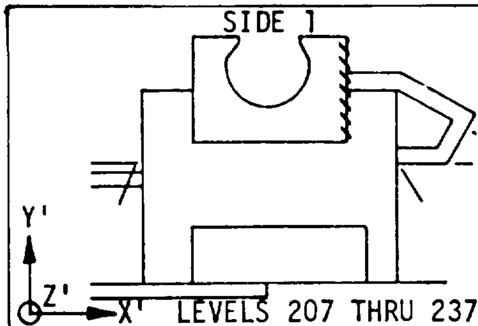
Sym.	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.03	2.1
B	Lift-off Steady State Until Umbilical Disconnect	0.07	3.3
C	Lift-off Peak	2.0	19.4



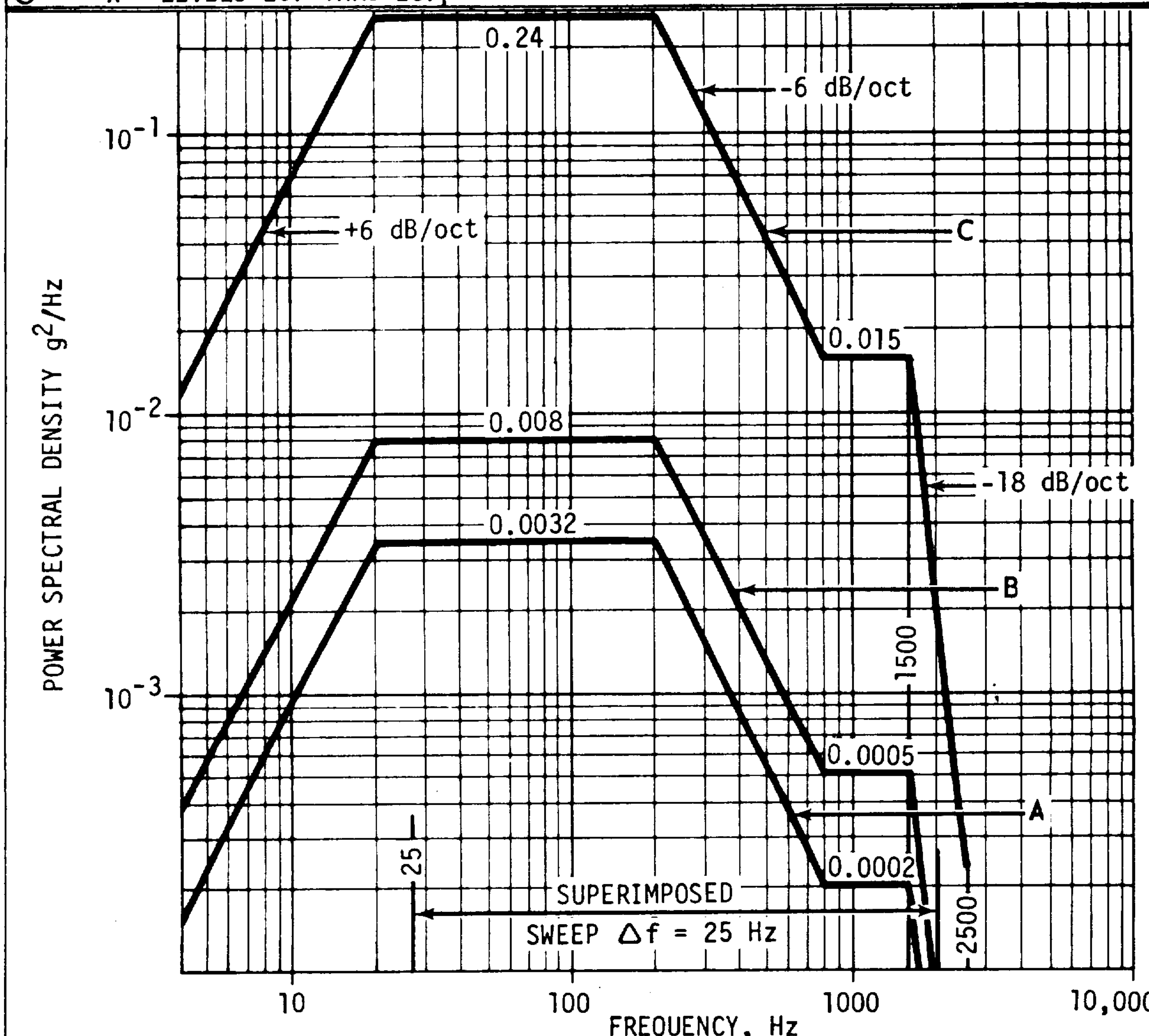
RANDOM VIBRATION ENVIRONMENT
ZONES 4.6.1, 4.6.2, 4.6.3, AND 4.6.4
RCS ROOM WALLS. GIRT STRUCTURE
Z' DIRECTION



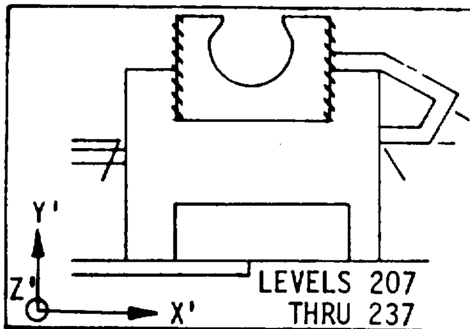
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.1
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.5
C	Lift-off Peak	0.3	7.2



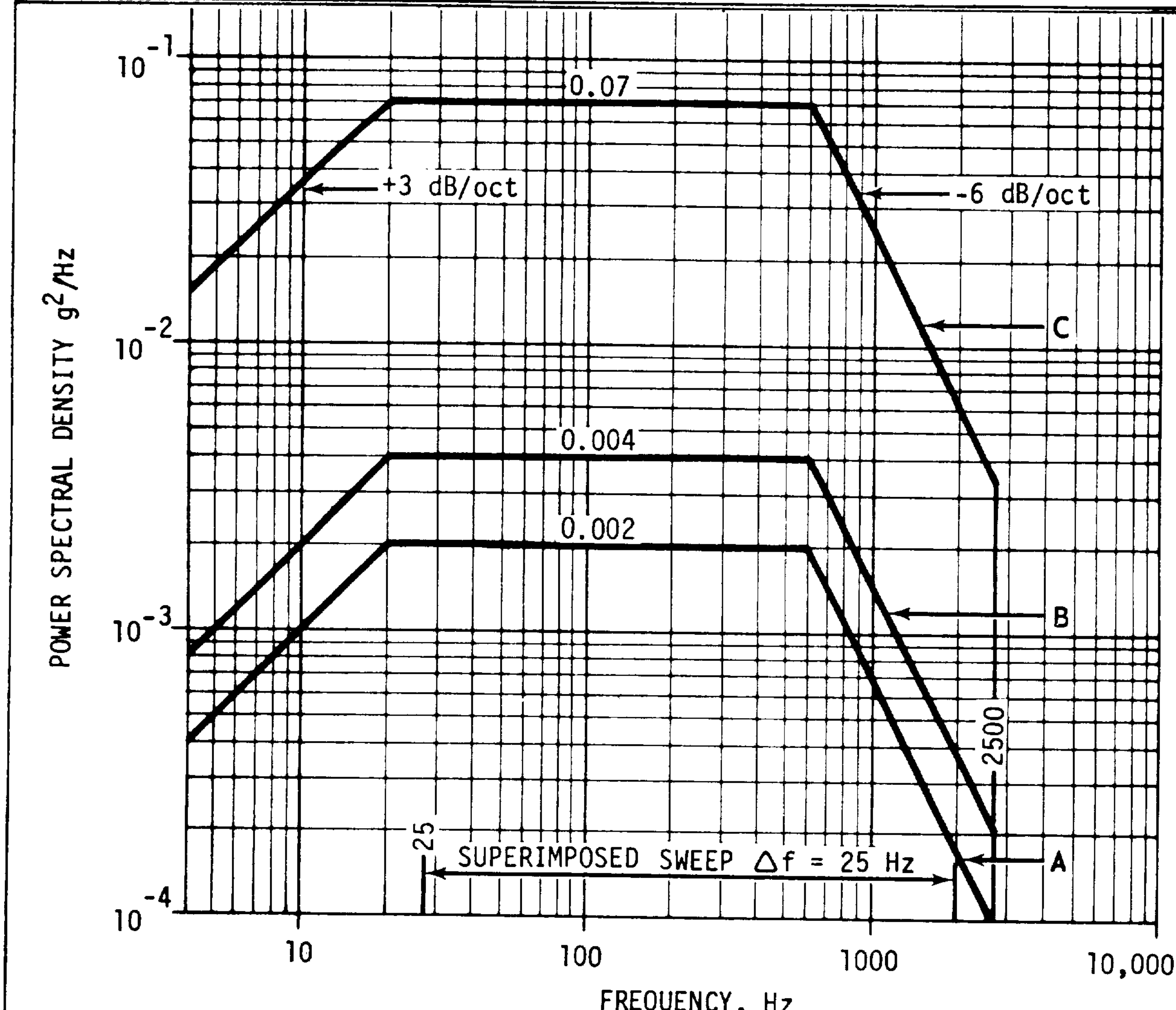
RANDOM VIBRATION ENVIRONMENT
ZONE 4.6.2
RCS ROOM WALL ON SIDE 2.
GIRT STRUCTURE
X' DIRECTION



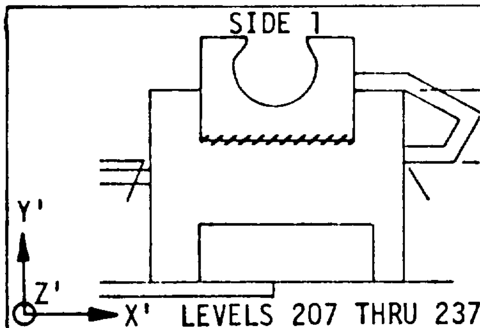
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.2
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.9
C	Lift-off Peak	0.3	10.1



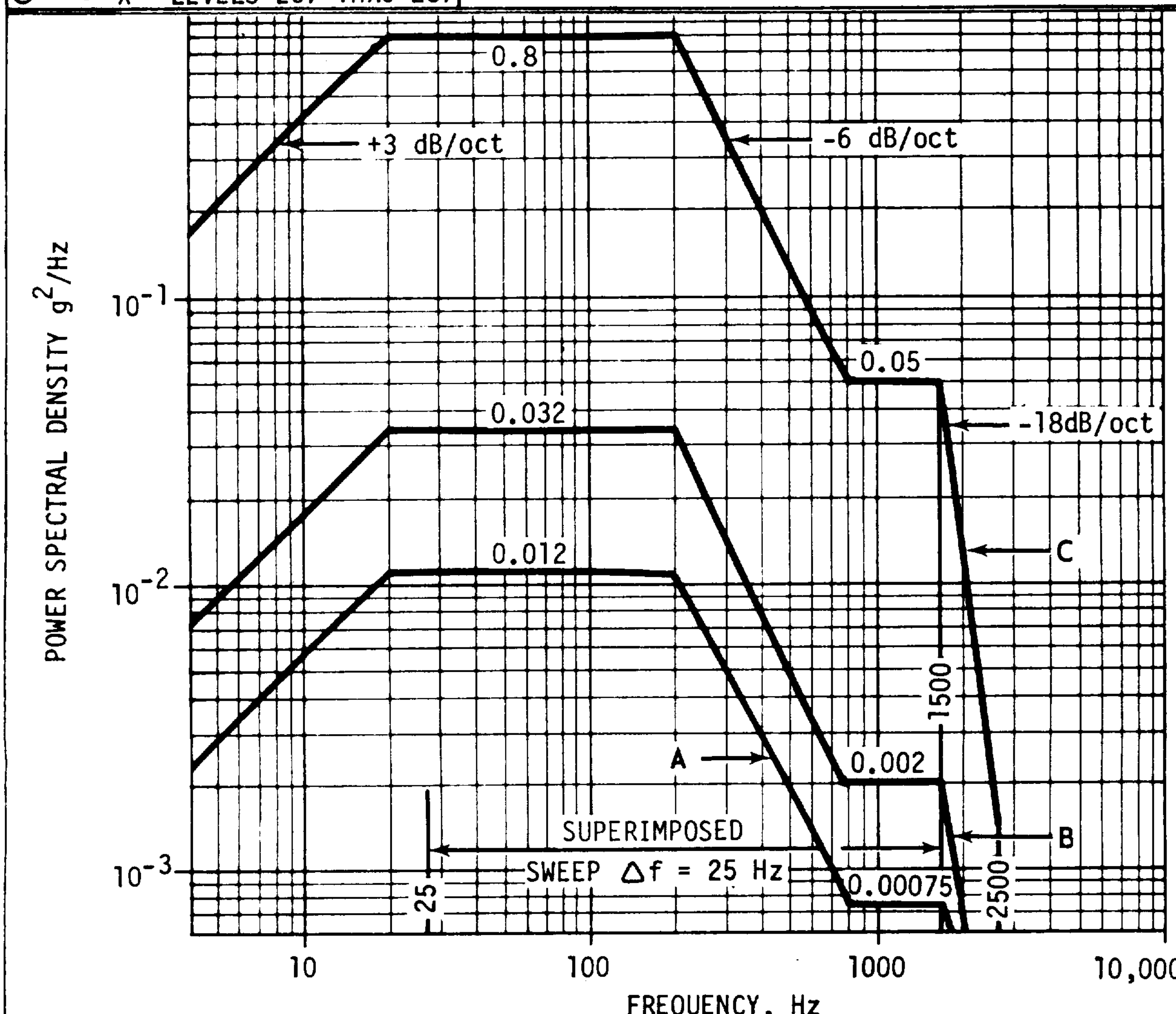
RANDOM VIBRATION ENVIRONMENT
ZONES 4.6.2 AND 4.6.4
RCS ROOM WALLS ON SIDES 2 AND 4.
GIRT STRUCTURE.
Y' DIRECTION



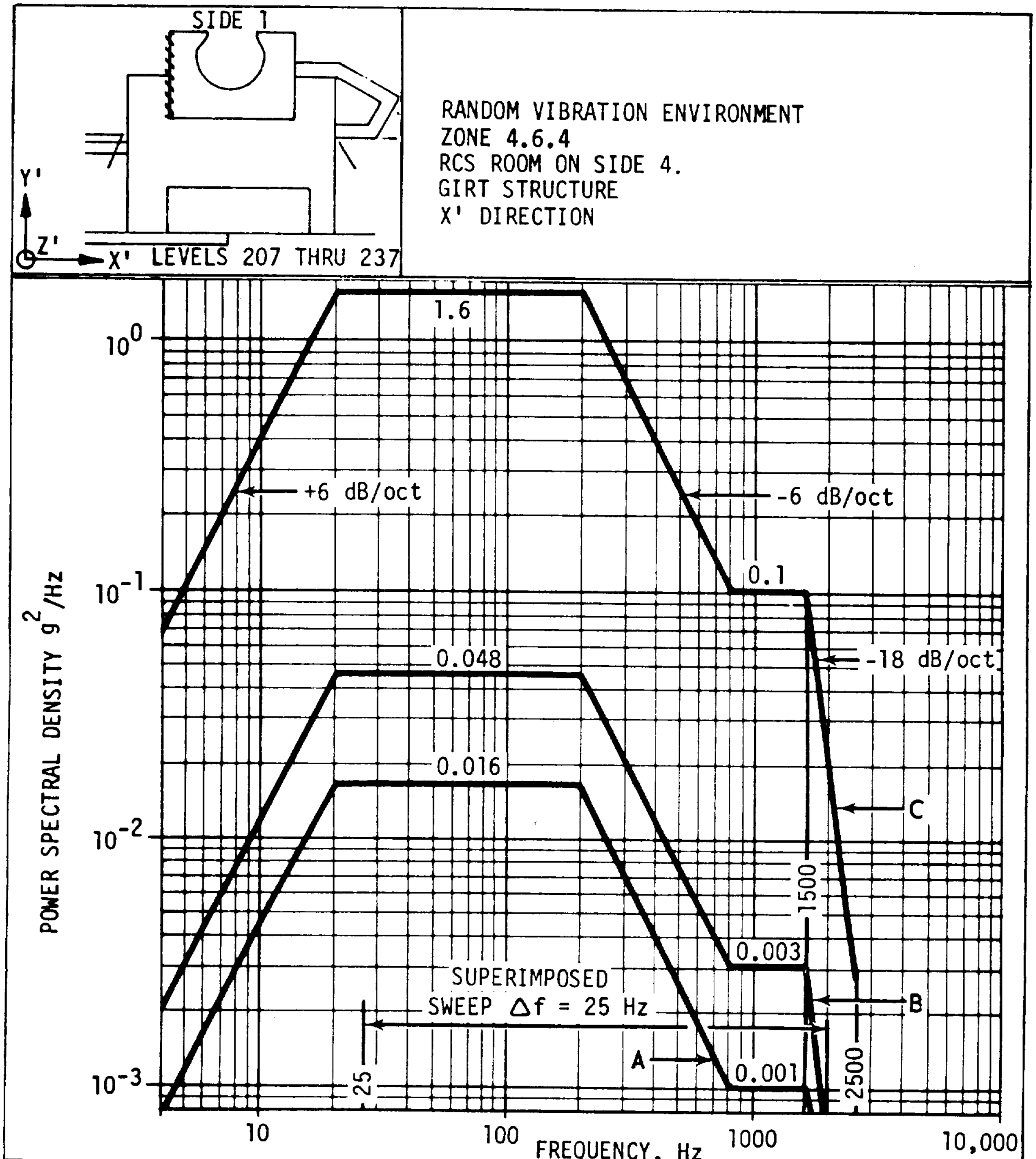
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.6
B	Lift-off Steady State Until Umbilical Disconnect	0.04	2.3
C	Lift-off Peak	0.2	8.8



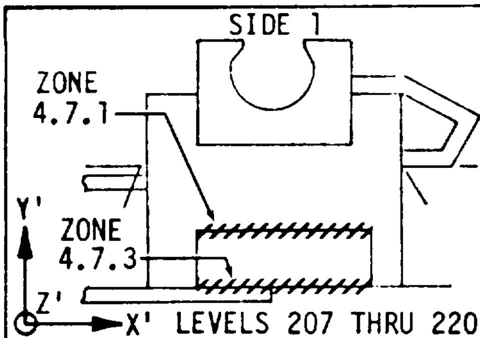
RANDOM VIBRATION ENVIRONMENT
ZONE 4.6.3
RCS ROOM WALL ON SIDE 3,
GIRT STRUCTURE
Y' DIRECTION



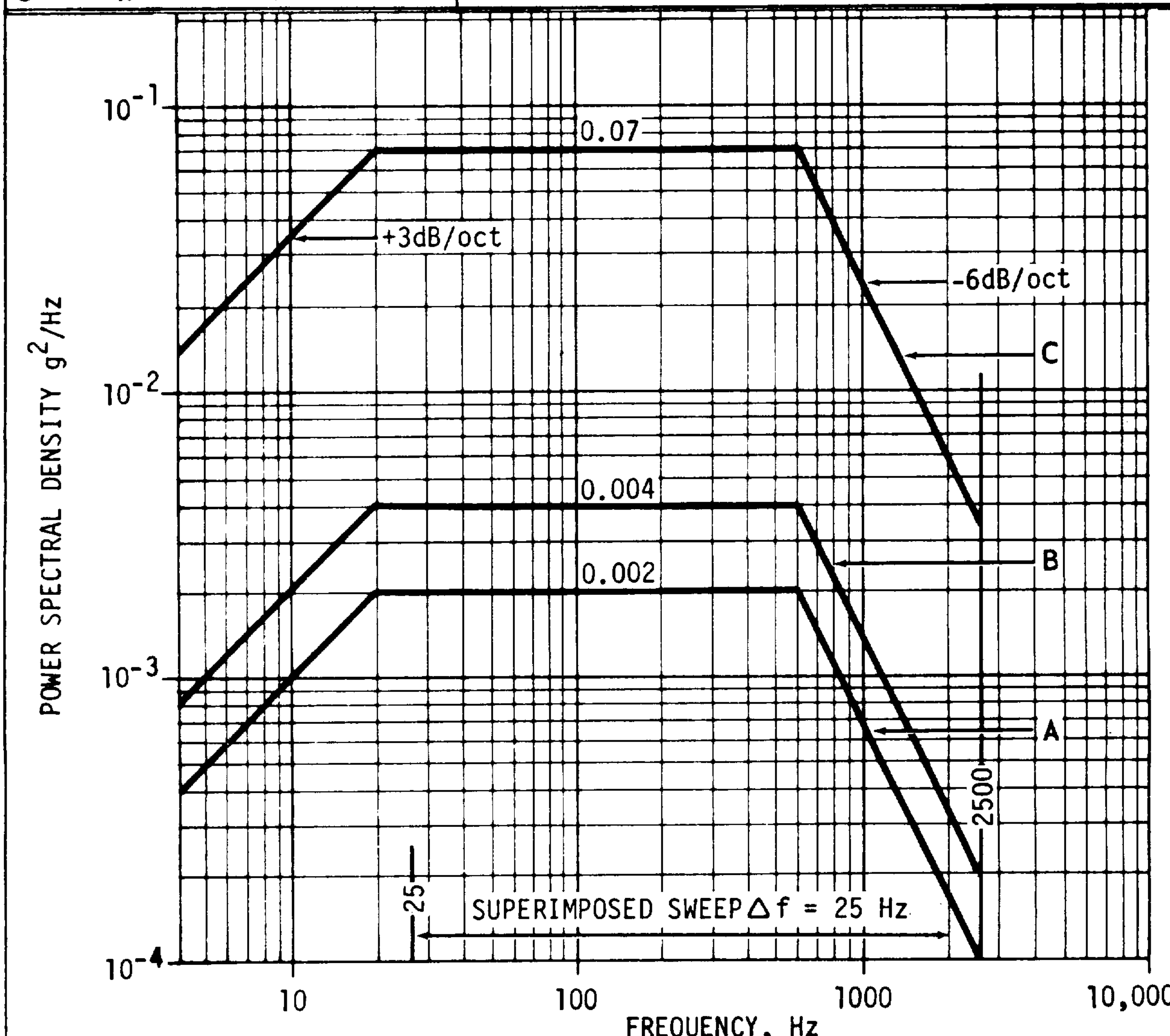
Sym.	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.04	2.4
B	Lift-off Steady State Until Umbilical Disconnect	0.1	3.9
C	Lift-off Peak	2.0	19.2



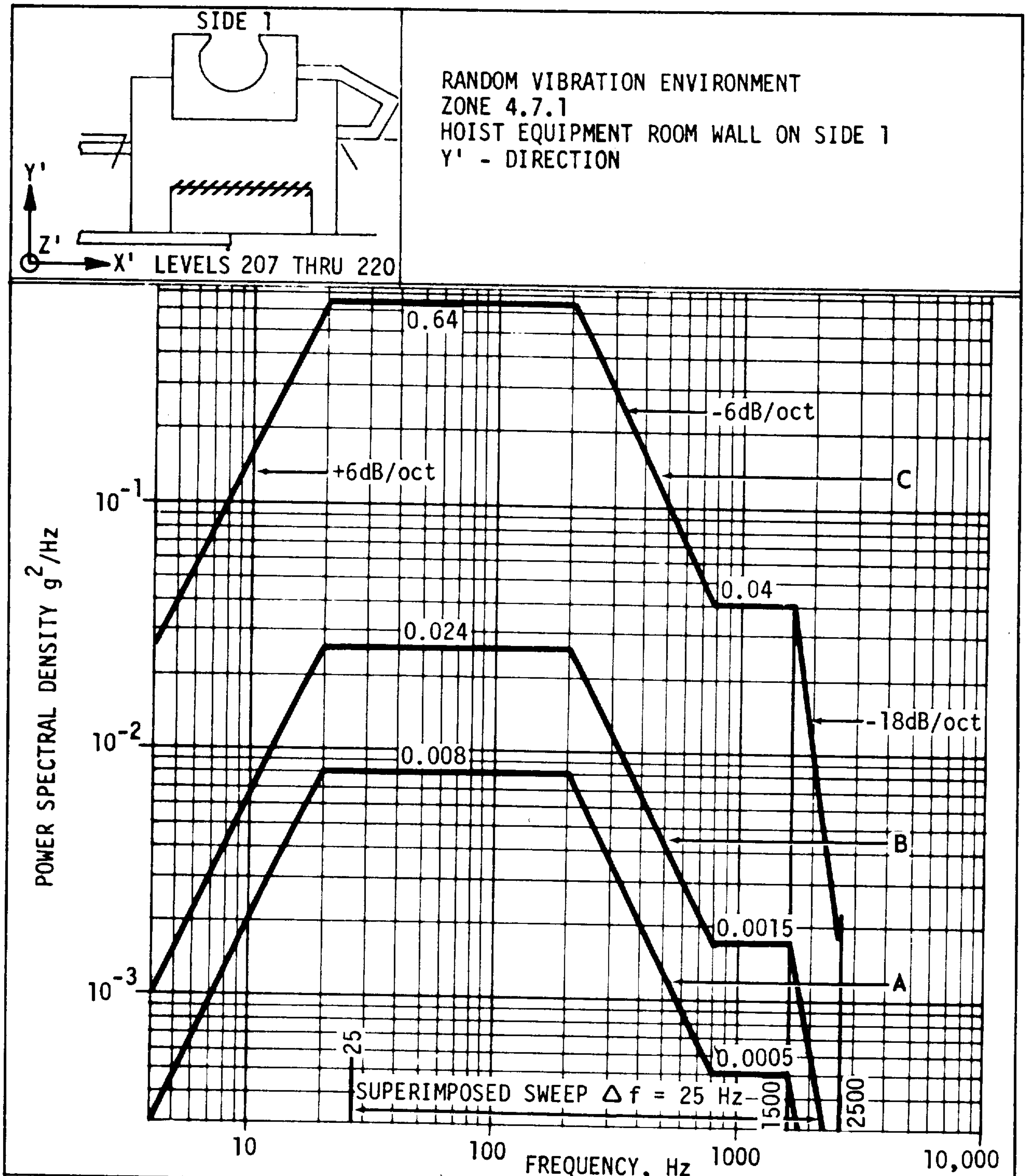
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.05	2.8
B	Lift-off Steady State Until Umbilical Disconnect	0.15	4.8
C	Lift-off Peak	2.0	26.2



RANDOM VIBRATION ENVIRONMENT
ZONES 4.7.1 and 4.7.3
HOIST EQUIPMENT ROOM WALLS ON SIDE 1
AND SIDE 3. GIRT STRUCTURE.
X' - DIRECTION

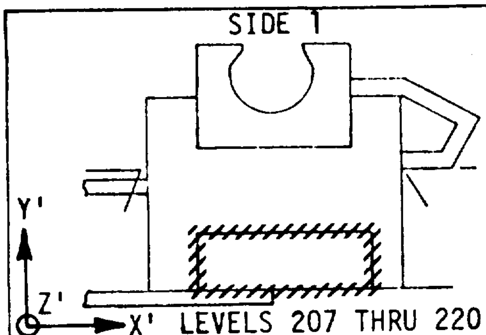


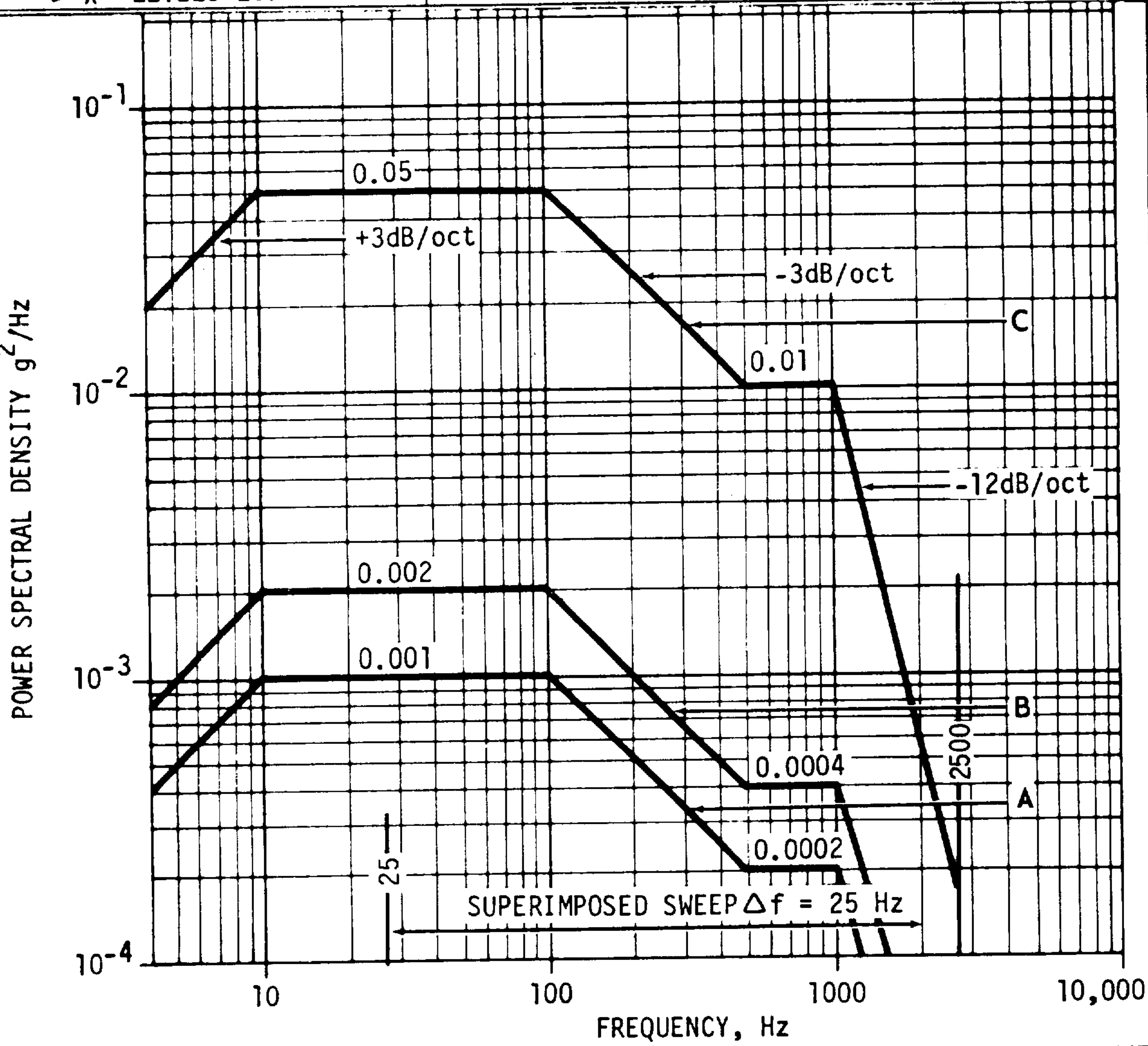
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.6
B	Lift-off Steady State Until Umbilical Disconnect	0.04	2.3
C	Lift-off Peak	0.2	8.8



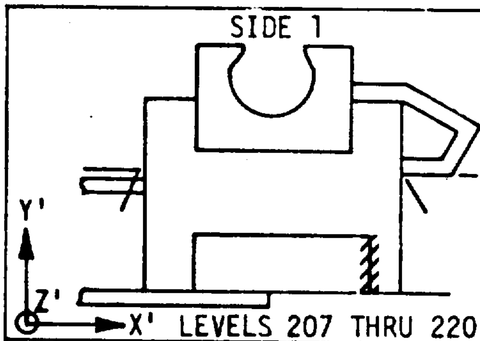
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.03	2.0
B	Lift-off Steady State Until Umbilical Disconnect	0.08	3.4
C	Lift-off Peak	0.8	16.6

RANDOM VIBRATION ENVIRONMENT
ZONES 4.7.1, 4.7.2, 4.7.3, and 4.7.4
HOIST EQUIPMENT ROOM WALLS.
GIRT STRUCTURE.
Z' DIRECTION

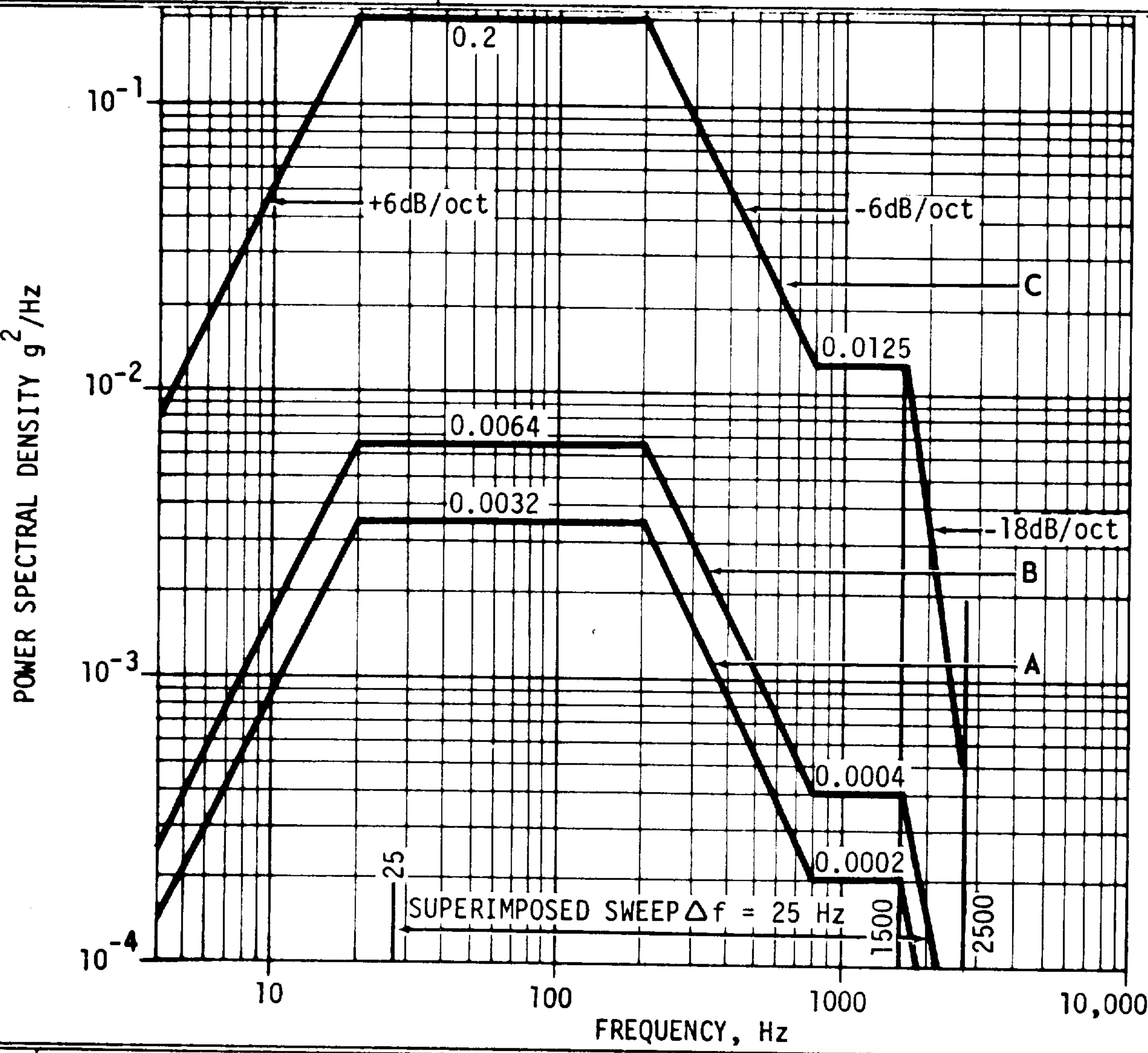




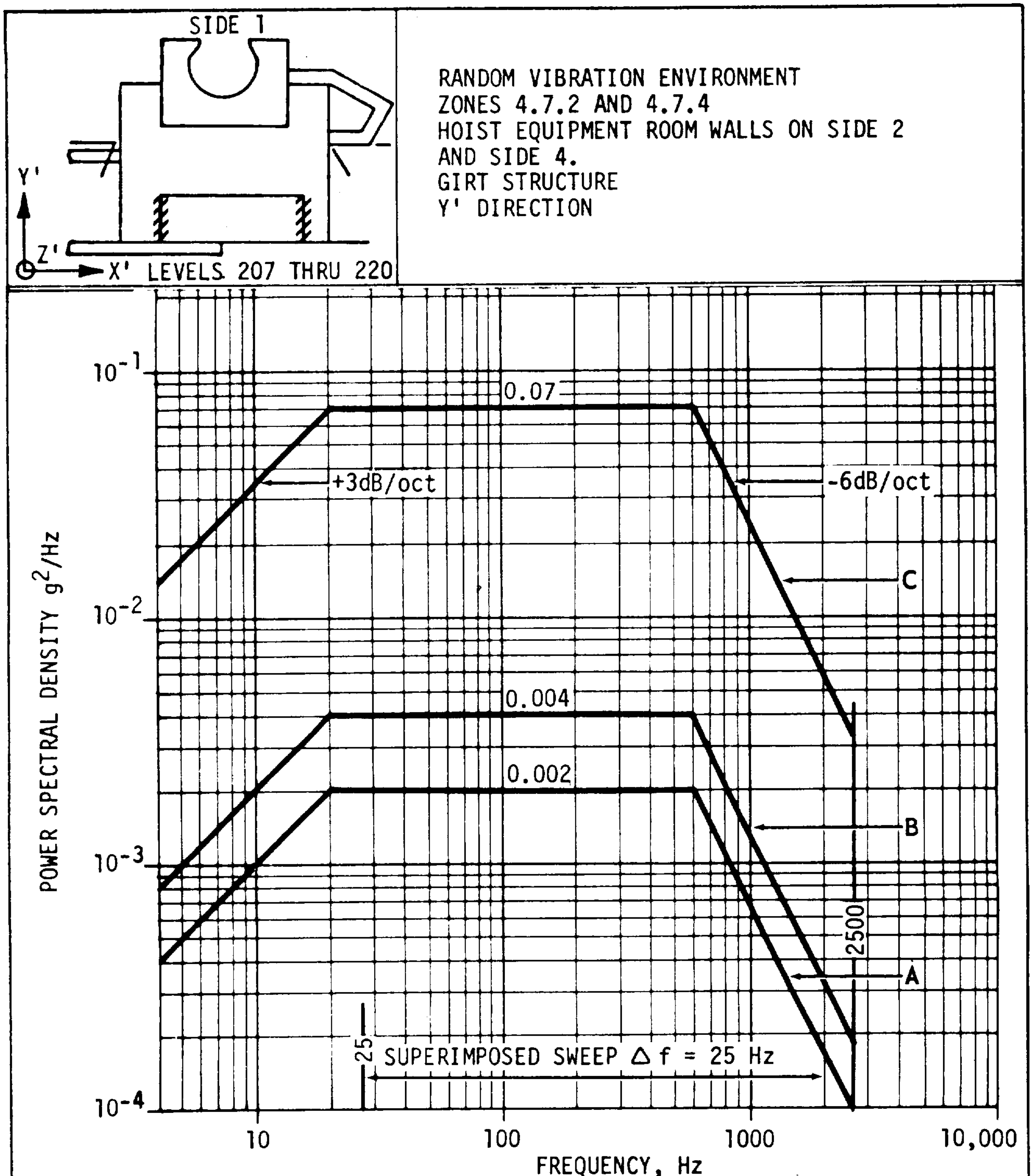
Sym	Launch Stage	Sweep ΔPSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	0.82
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.2
C	Lift-off Peak	0.2	5.1



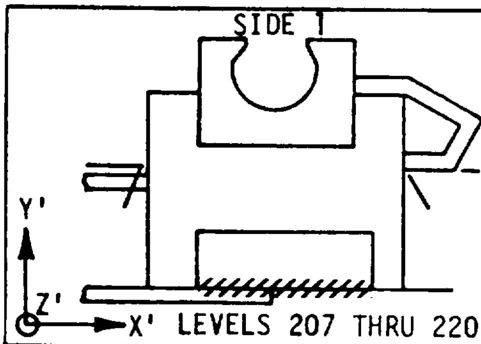
RANDOM VIBRATION ENVIRONMENT
ZONE 4.7.2
HOIST EQUIPMENT ROOM WALL ON SIDE 2
X' DIRECTION



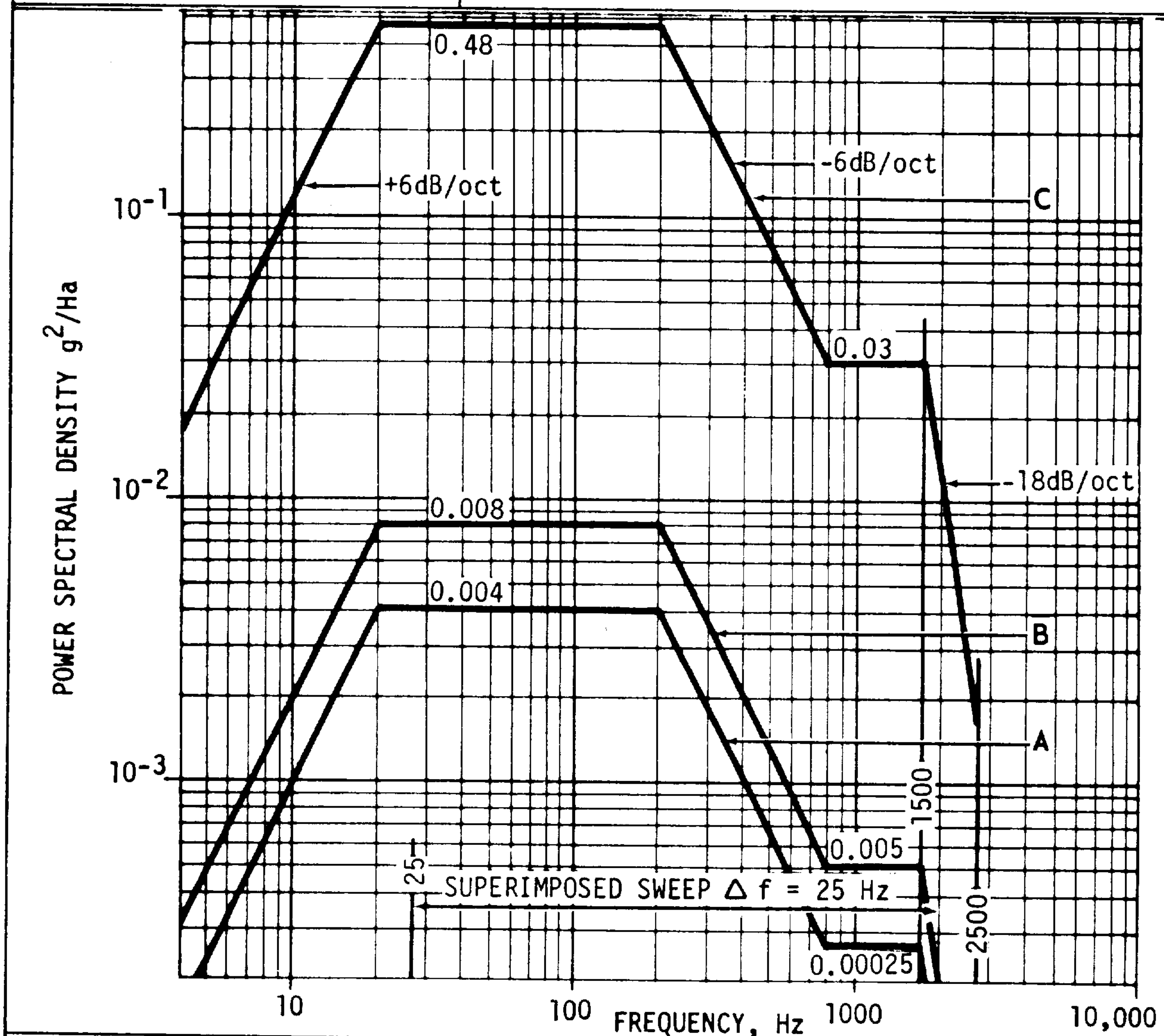
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.2
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.7
C	Lift-off Peak	0.3	9.3



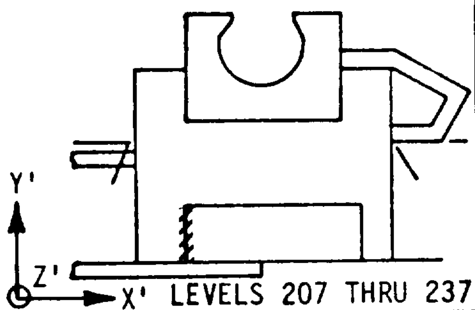
Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.02	1.6
B	Lift-off Steady State Until Umbilical Disconnect	0.04	2.3
C	Lift-off Peak	0.2	8.8



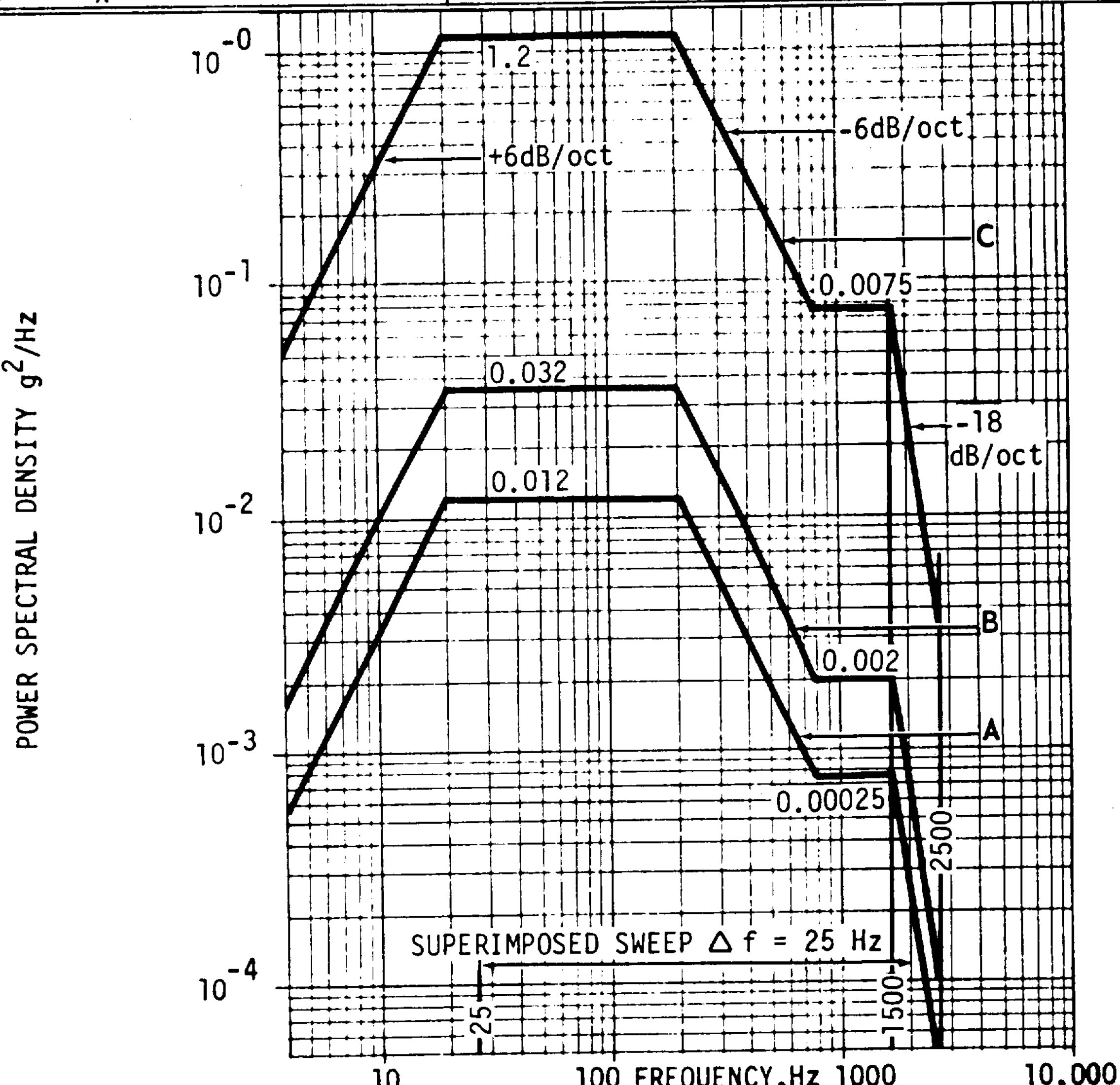
RANDOM VIBRATION ENVIRONMENT
ZONE 4.7.3
HOIST EQUIPMENT ROOM WALL ON SIDE 3.
GIRT STRUCTURE
Y' DIRECTION



Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.01	1.4
B	Lift-off Steady State Until Umbilical Disconnect	0.02	1.9
C	Lift-off Peak	0.8	14.5



RANDOM VIBRATION ENVIRONMENT
ZONE 4.7.4.
HOIST EQUIPMENT ROOM WALL ON SIDE 4.
GIRT STRUCTURE
X' DIRECTION



Sym	Launch Stage	Sweep Δ PSD g^2/Hz	Overall Level g_{rms}
A	Orbiter Holddown	0.04	2.4
B	Lift-off Steady State Until Umbilical Disconnect	0.1	3.9
C	Lift-off Peak	1.5	22.7

APPENDIX C

PREDICTION TECHNIQUES

C.1 ACOUSTIC ENVIRONMENT

Prediction of acoustic environment induced by the launch of the Space Shuttle from LC-39 is based on the empirical method of scaling the measured data obtained during the Saturn V/Apollo Program to the environment of the Shuttle. Empirical prediction schemes yield accurate results whenever the variation of the rocket engine parameters and the exhaust flow configurations between the reference and the new rocket is small, a condition satisfied in the case of Shuttle/Saturn V vehicles. Following is a brief description of the theory underlying the empirical method of scaling.

The kinetic energy (T) generated by the exhaust flow per second of time is:

$$T = 1/2\ mV^2 = 1/2\ FV \quad \text{(ft-lb/sec)} \tag{1}$$

Where

m = total mass flow of air and fuel through the engine in lb-sec/ft

V = F/m = effective exit velocity (ft/sec) calculated from the engine thrust F in lb

The empirical ratio of the radiated acoustic energy (T_A) of a jet to its total energy (T) defines the acoustic radiation efficiency (η). Thus,

$$T_A = \eta T \tag{2}$$

The variation of the acoustic radiation efficiency with the jet Mach number, and the acoustic efficiency of the various noise sources within a jet, are shown in figure C-1. The important feature of the acoustic radiation efficiency is that at Mach numbers greater than 3 the dominant Mach Wave Radiation remains essentially constant. Location of Saturn V, Orbiter and SRB engines on the diagram shows that both Shuttle and Saturn V vehicles have essentially the same acoustic radiation efficiency. Therefore, scaling of the Saturn V acoustic field to that of the Orbiter or SRB acoustic fields is independent of the acoustic radiation efficiency.

The overall acoustic power level in decibels, referenced to 10^{-13} watts, is given by:

$$\text{OAPWL} = 10 \log (1.356\eta T) + 130 \tag{3}$$

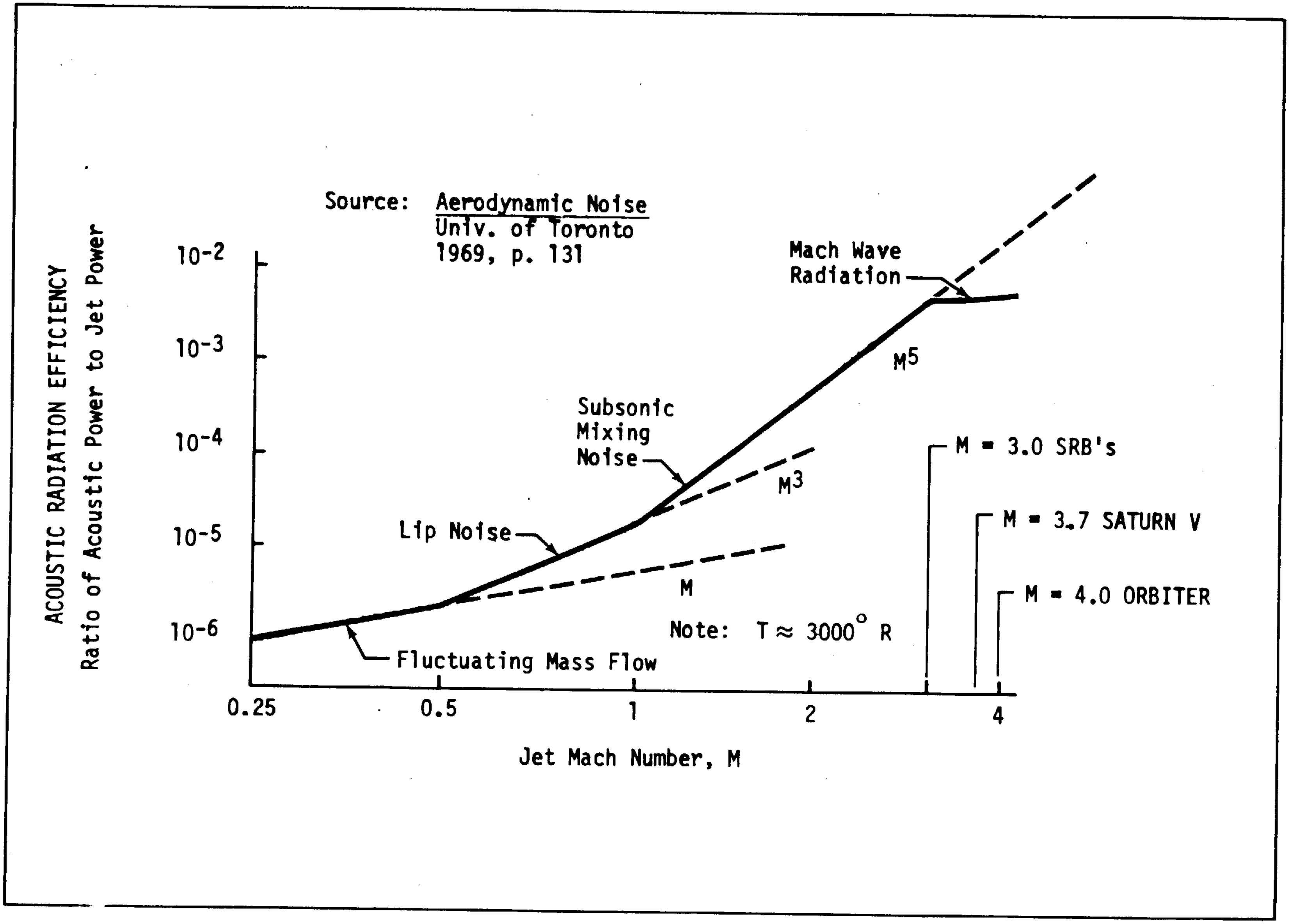


Figure C-1. Radiation Efficiency of Noise Sources in the Jet Exhaust

The overall sound pressure level in decibels, referenced to 0.0002 dynes/cm^2, is given by:

$$OASPL = OAPWL - 10 \log A + 0.5 \qquad (4)$$

Where

A = total surface area in square feet (measured at location of observer) through which the acoustic power is radiated.

The same relation given by Equation 4 holds between the octave band sound pressure levels and the octave band sound power levels.

Assuming similar atmospheric conditions, exhaust flow geometry and launch pad configurations, it follows from Equations 1 through 4 that the overall acoustic sound pressure levels for the new and reference vehicles, when measured at the same locations, are related by:

$$OASPL_{NEW} = OASPL_{REF} + 10 \log \frac{[FV]_{NEW}}{[FV]_{REF}} \text{ , dB} \qquad (5)$$

The effects of parameters η and A are cancelled out from Equation 5 by the previous assumptions. Equation 5 is fundamental in scaling acoustic fields at all distances greater than approximately two jet diameters from the jet boundary. At closer distances, acoustic fields are likely to be strongly affected by the detailed structure of the turbulent mixing regions, since the acoustic power per unit length varies along the jet and attains a maximum just downstream of the tip of the supersonic core.

The spectral distribution of acoustic power can be presented in a nondimensional form by plotting the power in each octave band referenced to the overall power levels as a function of nondimensional Strouhal number.

$$S = fD_e/V \qquad (6)$$

Where

f = octave band center frequency, Hz

D_e = effective exhaust diameter which accounts for the combined flow of clustered engines.

The basic assumption of the empirical method is that the normalized power spectrum remains invariant for a large class of rocket engines. Actual spectral distributions of the acoustic power from different engines, when normalized and plotted against the Strouhal number, should fall on the same curve. The spectra are shifted relative to each other by the difference in their Strouhal numbers. Conversely, the same Strouhal number on the normalized spectrum corresponds to a different octave band center frequency on the actual spectrum of different engines. Figure C-2 shows normalized acoustic power level spectra for the near and far fields. The shift between the two curves is due to atmospheric attenuation of sound power levels with the distance from exhaust plumes.

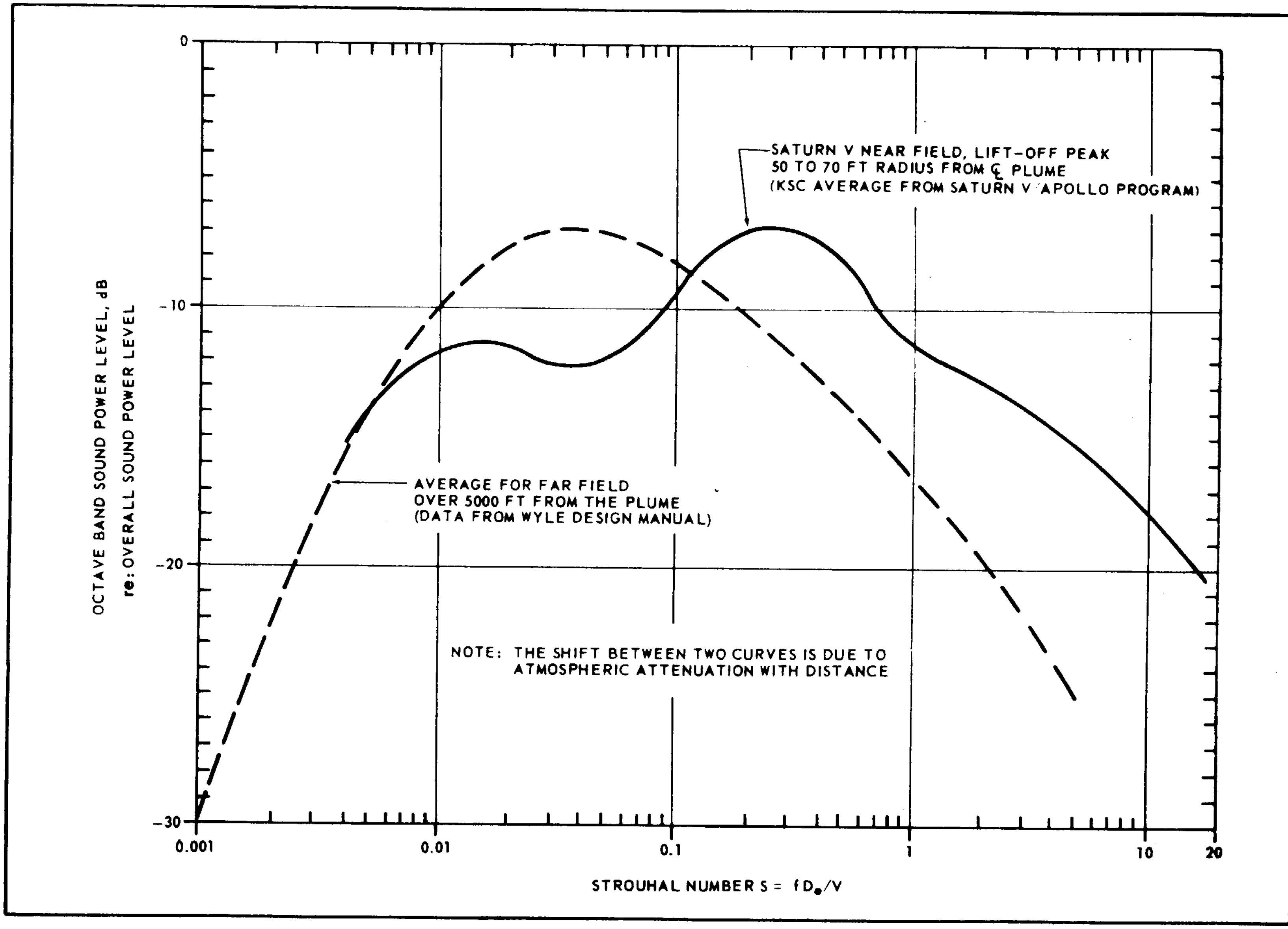


Figure C-2. Nondimensional Rocket Exhaust Acoustic Power Level Spectrum For Free Undeflected Flow.

When scaling from the referenced to a new rocket engine, there is no need to determine the normalized spectrum. Scaling is simply performed by using Equation 5 for the new value of the OBSPL, and by equating two Strouhal numbers corresponding to the same abscissa of the normalized spectrum to obtain the frequency shift of the new spectrum with respect to the referenced one. The frequency shift is given by:

$$f_{NEW} = f_{REF} \frac{[D_{\bullet}/V]_{REF}}{[D_{\bullet}/V]_{NEW}} \tag{7}$$

When comparing Shuttle SSME and SRB plumes with that of Saturn V, the comparison must be made separately between the SSME plume and a part of the Saturn V plume corresponding to SSME plume, and similarly between the SRB plume and the remaining part of the Saturn V plume. This approach is required in order to define parameter $D_{\bullet}$. For clustered engines, $D_{\bullet} = D\sqrt{N}$, where N = number of engines in the cluster. Configurations of Saturn V and Shuttle flame deflectors suggest that one-half of the Saturn V plume (2-1/2 F-1 engines) be compared with the Orbiter plume (3 SSME's) and SRB plume (2 SRB's). These considerations, together with equations 5 and 7 and the rocket engine parameters given in table C-1, yield the following equations used to predict Shuttle acoustic environment at the locations where Saturn V measurements were available:

$$\left.\begin{aligned} OBSPL_{SSME} &= OBSPL_{SAT\ V} - 7.28 \quad , \quad dB \\ OBSPL_{SRB} &= OBSPL_{SAT\ V} - 2.93 \quad , \quad dB \end{aligned}\right\} \tag{8}$$

$$\left.\begin{aligned} f_{SSME} &= 1.58 f_{SAT\ V} \\ f_{SRB} &= 0.83 f_{SAT\ V} \end{aligned}\right\} \tag{9}$$

Calculated OBSPL's for Orbiter and SRB's are converted to mean square pressures at the standard octave band center frequencies and are added together to depict the effect of the total Shuttle plume. All calculations using Equations 8 and 9 were made with the statistical averages (mean values) given in SP-4-38-D[1]. Figures C-3, C-4, and C-5 illustrate the results of analysis for locations corresponding to Saturn V launch umbilical tower (LUT). The predicted levels during the peak environment are approximately 1.5 dB below those of Saturn V. The effect of the frequency shift in the Shuttle spectra is very small, which makes assumptions used in the derivation of Equation 9 noncritical and, probably, within the accuracy of the analysis.

The prediction of the acoustic field for the SSAT and PCR was derived from the prediction for locations at Saturn V LUT by considering the effect of distance between these structures and the combined plume of the Shuttle, assuming nominal trajectory and drift to the North.

Variation of the acoustic spectra with the distance in the near field is nonlinear, and it does not follow the inverse square law. The required correction was interpolated from Saturn V measurements on the LUT and at 150 ft radius.

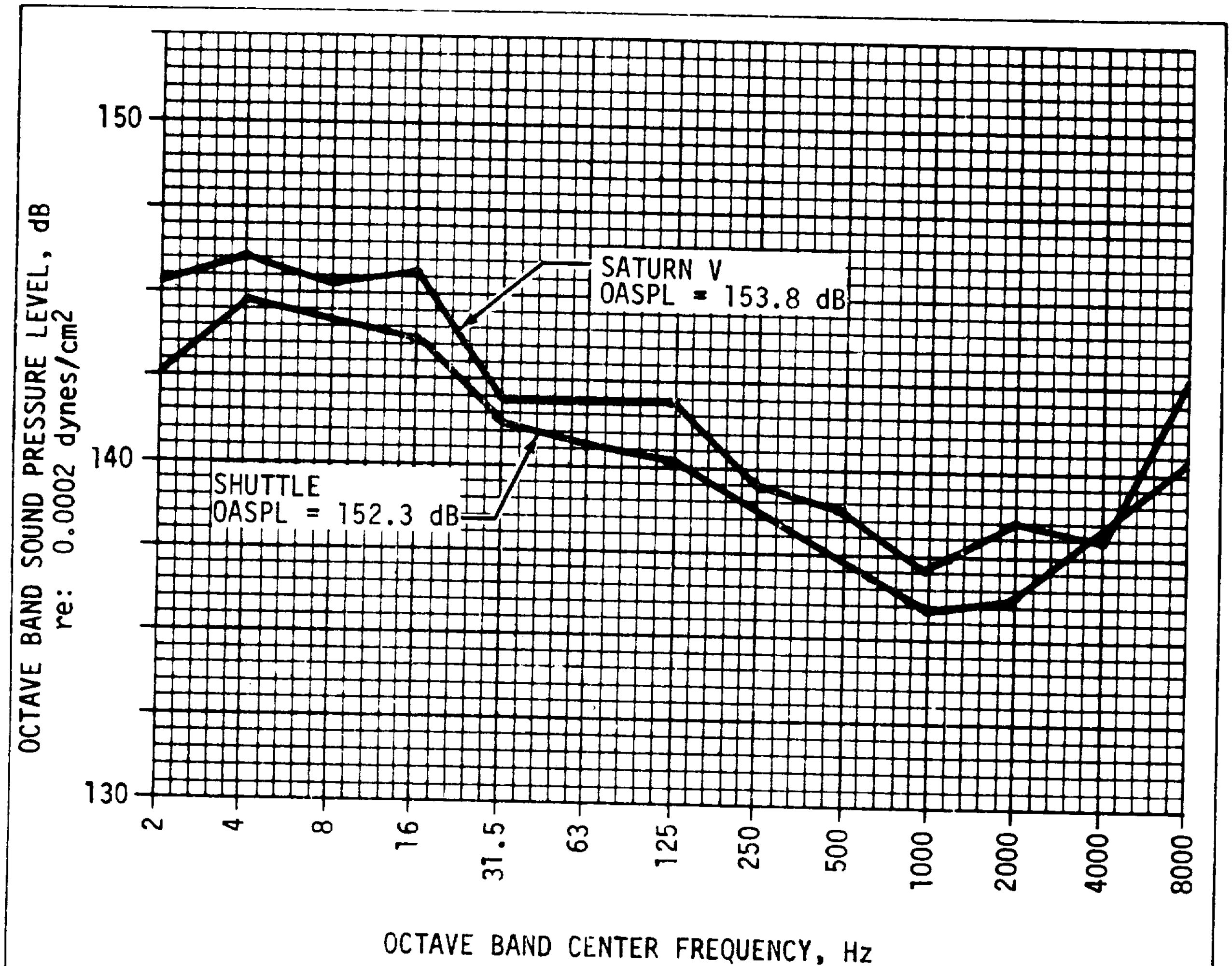
Table C-1. Rocket Engine Parameters

Parameter	Symbol	Saturn V	Space Shuttle	
		F-1	SRB	SSME
Number of Engines	N	5	2	3
Nozzle Exit Diameter, Inches	D	139.8	141.7	92.0
Exhaust Velocity at Sea Level, ft/sec	V	8550.0	6440.0	9730.0
Exhaust Velocity in Vacuum, ft/sec	V_υ	10500.0	7900.0	11940.0
Exit Mach Number	M	3.7	3.0	4.0
Supersonic Core Length, ft $L = 3.45D\ (1+0.38M)^2$	L	233.0	187.0	168.0
Engine Thrust, lbs/engine	F	1.522 E06	2.575 E06	4.173 E05
Exhaust Power at Sea Level Per Engine, W = FV, ft-lb/sec	W	1.302 E10	1.658 E10	4.06 E09
Total Generated Power at Lift-Off, ft-lb/sec	W_T	6.51 E10	3.317 E10	1.218 E10
Strouhal Number $S = fD\sqrt{N_e}/V$ N_e = Number of Engines for Plume Comparison	Saturn V (2.5-F-1's) Boosters (2-SRB's) Orbiter (3-SSME's)	S = 0.002153 f (Saturn V) 0.002594 f (SRB) 0.001365 f (SSME)		
OAPWL Scaling Ratio:	OAPWL (Orbiter) = OAPWL (Saturn V) - 7.28 dB OAPWL (SRB's) = OAPWL (Saturn V) - 2.93 dB Referenced to Saturn V OAPWL			
Spectral Distribution Frequency Shift:	f (SRB's) = 0.83 f (Saturn V) f (SSME's) = 1.58 f (Saturn V)			

REMARKS: PREDICTION FOR SHUTTLE IS FOR THE SAME LOCATIONS ON THE UMBILICAL TOWER WHERE THE DATA FOR SATURN V WERE MEASURED.

CURVES REPRESENT AVERAGE VALUES (50% CONFIDENCE LEVEL)

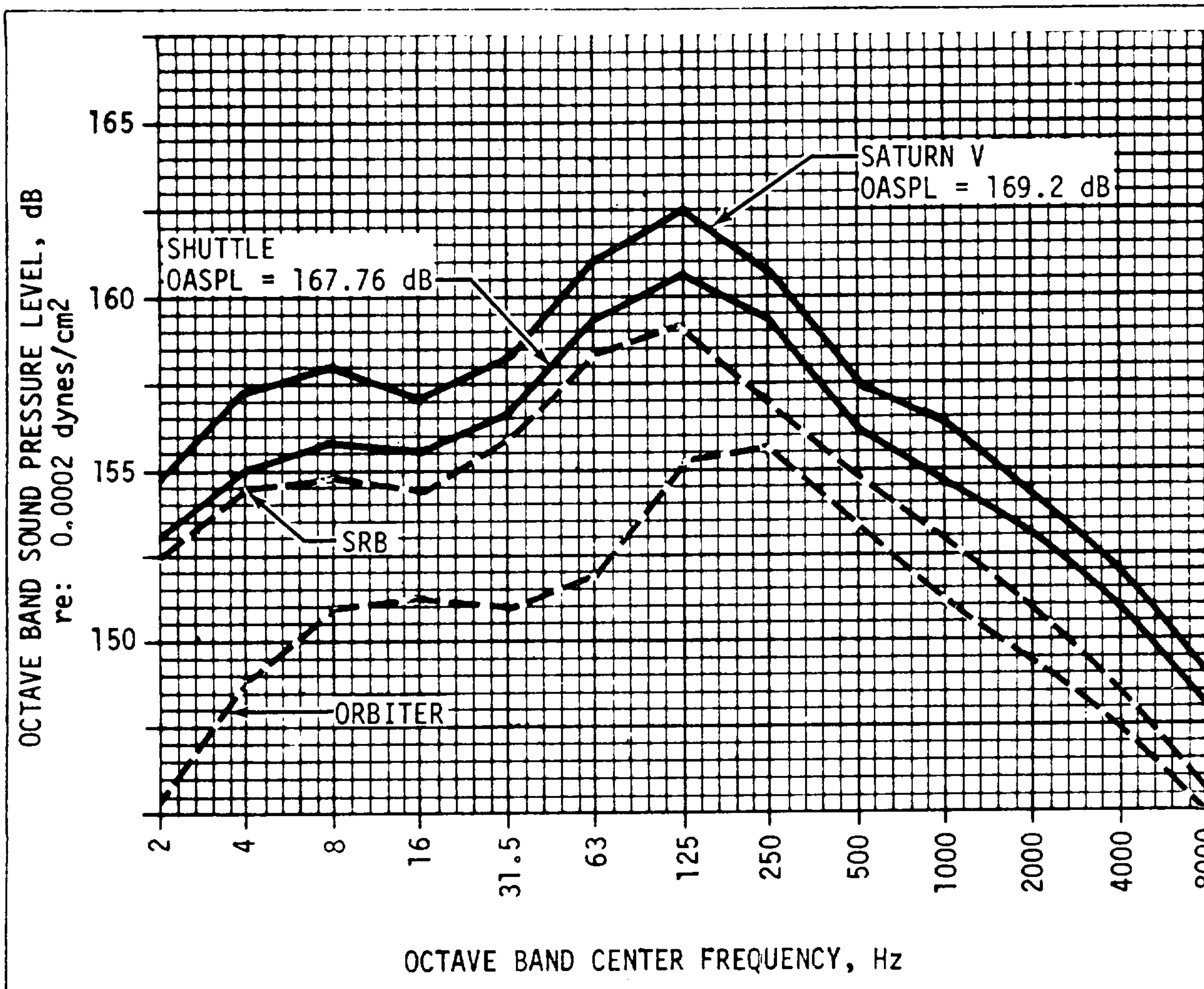
Figure C-3. Comparison of Shuttle and Saturn V Acoustic Environments (Orbiter and Saturn V Holddown).



REMARKS: PREDICTION FOR SHUTTLE IS FOR THE SAME LOCATIONS ON THE UMBILICAL TOWER WHERE THE DATA FOR SATURN V WERE MEASURED.

CURVES REPRESENT AVERAGE VALUES (50% CONFIDENCE LEVEL)

Figure C-4. Comparison of Shuttle and Saturn V Acoustic Environments (Pseudo Steady State Prior to Peak at Lift-Off).



REMARKS: PREDICTION FOR SHUTTLE IS FOR THE SAME LOCATIONS ON THE UMBILICAL TOWER WHERE THE DATA FOR SATURN V WERE MEASURED.

CURVES REPRESENT AVERAGE VALUES (50% CONFIDENCE LEVEL)

Figure C-5. Comparison of Shuttle and Saturn V Acoustic Environments (Lift-Off Peak).

The specification curves (97.7 percent C.L.) were obtained from the derived mean curves assuming that the same dispersion will occur during Shuttle launches as that measured for Saturn V. The difference between the two curves (mean and specification) calculated for Saturn V from the statistical analysis was added to the predicted mean OBSPL curves for Shuttle to yield 97.7 percent C.L. Shuttle specifications.

C.2 VIBRATION ENVIRONMENT

The general solution for the response of a structure to an external random acoustic excitation may be obtained in terms of normal modes of the structure in the form:

$$\begin{aligned} S_w(\omega) &= \sum_n \frac{\phi_n^2(r)}{|Z_n(\omega)|^2} \int_A \phi_n(r_1) \int_A \phi_n(r_2) S_p(r_1, r_2, \omega) dA_2 dA_1 \\ &+ \sum_n \sum_{\substack{m \\ n \neq m}} \frac{\phi_n(r)\phi_m(r)}{Z_n(\omega) Z_m^*(\omega)} \int_A \phi_n(r_1) \int_A \phi_m(r_2) S_p(r_1, r_2, \omega) dA_2 dA_1 \end{aligned} \tag{10}$$

Where

$S_w(\omega)$ = power spectral density of the displacement response at point r and shown as a function of the circular frequency ω

$\phi_n(r), \phi_m(r)$ = n-th and m-th normal modes of the structure defining modal displacements at point r

$Z_n(\omega)$ = $M_n[(\omega_n^2-\omega^2)+i2\zeta_n\omega_n\omega]$ is the complex obstructance of the structure in the n-th mode

M_n = generalized mass of the structure corresponding to the n-th mode

ω_n = circular resonance frequency of the n-th mode

ζ_n = damping coefficient in the n-th mode, fraction of critical damping

i = $\sqrt{-1}$

$Z_m^*(\omega)$ = complex conjugate of $Z_m(\omega)$

$S_p(r_1, r_2, \omega)$ = cross-power spectral density of acoustic pressures at points r_1 and r_2, function of the circular frequency ω. This quantity is complex, but only the real part enters into the first series. In the second series, both real and imaginary parts contribute but the final result is real.

A = area of the structure subjected to acoustic excitation

The first series gives the sum of the spectra of the responses in the individual modes. The double integral in this series is the power spectrum of the n-th generalized force. For a homogeneous acoustic field it may be written as:

$$A^2 S_p(\omega) J_n^2(\omega) \tag{11}$$

Where

$S_p(\omega)$ = power spectral density of acoustic pressure

$J_n(\omega)$ = joint acceptance of the n-th mode defined by the above transformation

The second double summation in Equation 10 is a correction term which represents the response due to modal frequency overlap. Evaluation of this series is extremely difficult and it appears that only statistical estimates are possible. When only a few modes participate in the response of the structure and their natural frequencies are widely separated, the second series is neglected. Thus, Equation 10 is reduced to:

$$S_w(\omega) = A^2 S_p(\omega) \sum_n \frac{\phi_n^2(r)}{|Z_n(\omega)|^2} J_n^2(\omega) \tag{12}$$

The above form is widely used in calculations of response for simple structures; however, Equation 10 provides a better insight into the physics of the phenomenon.

The velocity and acceleration response power spectra are related to the displacement spectra by the following:

$$S_{\dot{w}}(\omega) = \omega^2 S_w(\omega) \quad \text{(velocity spectrum)} \tag{13}$$

$$S_{\ddot{w}}(\omega) = \omega^4 S_w(\omega) \quad \text{(acceleration spectrum)} \tag{14}$$

The response of actual structures is multimodal. When a complex structure is excited by random forces with a wide frequency spectrum,a very large number of modes contributes to the response spectrum. It is generally impossible to compute the normal modes and frequencies of such a structure over the entire frequency range. Calculations of generalized forces or the joint acceptance are limited by the availability of measured narrow band space-time pressure correlation functions as well as by the extent of modal analysis. Therefore, the success of application of the analytical techniques is limited to a narrow range of simple structural components and to their responses in the few lowest modes. Whenever measurements on a full scale structure are available, it is sometimes possible, and more realistic, to use scaling techniques based on analytical solutions.

It was shown in figures C-3 thru C-5 that the input pressure spectra which occur during various stages of the Shuttle launch remain similar to the corresponding spectra of Saturn V. The coefficient of proportionality between these pressure spectra may be taken as the ratio between the mean square pressures or jet exhaust powers. In case of the MLP and SSAF structures which remain similar to the launch supporting structures used for Saturn V, the application of Equations 12 thru 14 allows the summation terms to be cancelled out from the scaling factors. The equation defining scaling may be written as:

$$[S(\omega)]_{SHUTTLE} = [S(\omega)]_{SAT\ V} \cdot \frac{[S_p(\omega)]_{SHUTTLE}}{[S_p(\omega)]_{SAT\ V}} \tag{15}$$

Where

$S(\omega)$ represents any vibrational response measured on Saturn V launcher and tower

The scaling factor, equal to the ratio of acoustic pressure input spectra, should be estimated for each location where scaling is applied considering the type of input most probably affecting the response of the structure at that location.

The following considerations governed the establishment of scaling factors for the MLP:

A. Comparison of Shuttle versus Saturn V overall jet power levels. Scaling factors may be calculated from the ratio of jet powers by:

$$SF(1) = \frac{[FV]_{SHUTTLE}}{[FV]_{SAT\ V}} \tag{16}$$

The affected region is at all distances beyond approximately two plume diameters from the centerline of the plume.

B. Comparison of Shuttle versus Saturn V acoustic energy flux density in the immediate vicinity of the plume.

The area through which the acoustic energy is radiated is assumed to be proportional to the area of the supersonic core, which, in turn, is proportional to the effective engine nozzle diameter, D_e, and the length, L, of the supersonic core. The acoustic energy density flux at the boundary of the supersonic core is:

$$E = \beta \cdot \frac{\eta FV}{D_e L} \tag{17}$$

Where

β is the coefficient of proportionality. The scaling factors in the vicinity of SSME or SRB plumes are calculated by:

$$SF(2) = \frac{[FV]_{SHUTTLE}}{[FV]_{SAT\ V}} \cdot \frac{[D_e L]_{SAT\ V}}{[D_e L]_{SHUTTLE}} \tag{18}$$

Where

D_e for Saturn V and SSME is calculated considering clustered engines.

The affected region lies in the vicinity of the exhaust wells where the local vibrational modes are excited mainly by the local acoustic input. There is a possibility that some superposition of the inputs from the SRB's will increase the above factors in the area between the SRB exhausts. However, the increase cannot exceed 60 percent of the values given by Equation 18.

C. The effect of different flame deflectors suggests comparison of jet powers from 2 SRB's (or 3 SSME's) with one-half of the total Saturn V power. The expression for the scaling factor, SF(3), has the same form as Equation 16 except that the denominator is reduced by one-half. The affected regions are local, mainly portions of deck B and North and South sides of the MLP. The duration of the effect is limited to an early stage of the lift-off and to the time before the peak vibrational environment occurs.

The scaling factors for the SSAF were calculated from Equation 15 by substituting the ratio of corresponding overall mean square pressures for the ratio of acoustic spectra. The substitution yields:

$$SF(4) = 10^{\Delta SPL/10} \tag{19}$$

Where

$$\Delta SPL = OASPL_{SHUTTLE} - OASPL_{SAT\ V}\ ,\ dB$$

The summary of the calculated scaling factors for the MLP and SSAF is shown in the table C-2. The values of scaling factors SF(1) and SF(4) represent a numerical comparison of vibrational environments induced by the Shuttle and Saturn V launches. These factors are applicable for scaling the measured acceleration PSD curves from Saturn V launches to the Shuttle environment on the major portion of the MLP and SSAF. The values SF(2) and SF(3) represent expected local peaks in the Shuttle vibrational environment which are limited to the portions of the MLP where the response is predominantly due to the local acoustic input.

Table C-2. Summary of Scaling Analysis

Structure	Rationale for Scaling Analysis		Scaling Factors on Acceleration Response PSD of Saturn V
MLP	SF(1)	Total generated acoustic power	Orbiter/Saturn V 0.19 2-SRB's/Saturn V 0.51 Shuttle/Saturn V 0.70
	SF(2)	Acoustic energy density flux in the immediate vicinity outside of the supersonic core	Orbiter/Saturn V 0.51 1 - SRB/Saturn V 0.70 Superposition effect may increase these factors by 60%. Superposition will occur over MLP area between SRB exhaust openings. Maximum scaling factor is 1.12
	SF(3)	Acoustic power generated by SSME's or SRB's considering splitting effect of flame deflector. Deflected orbiter plume is compared with 1/2 of Saturn V plume. Deflected plume from 2-SRB's is compared with 1/2 of Saturn V plume.	Orbiter/2-1/2 F-1's 0.38 2-SRB's/2-1/2 F-1's 1.02
SSAT	SF(4)	Comparison between acoustic fields at Saturn V LUT and SSAT during characteristic time intervals of a launch.	Orbiter holddown/Saturn V holddown 0.19 Pseudo-steady state/Saturn V holddown 0.59 Lift-off peak/Saturn V lift-off peak 0.62

Although different rationales were used to estimate scaling factors for the MLP, the variation between the extreme values of the scaling factors applicable at the same characteristic time intervals of a launch is less than the dispersion of the measured data defining a Saturn V zone. The equations used to derive scaling factors do not account for the effect of transmission of vibration throghh the structure, which should reduce the difference between the extreme values of the scaling factors. Therefore, engineering judgment was used to aid the final selection of a scaling factor and to interpolate between the limiting values calculated in table C-2.

The final steps in the derivation of vibration specifications were to comply with the requirements pertinent to the use of these specifications for testing of GSE as outlined in the following.

The specifications must reflect the actual vibration environment in a simplified form. The shape of the specified PSD curve should allow the equalization time to be minimized and the number of different PSD shapes should be reduced. Most of the measured data from the Saturn V Program shows similar PSD response curves for holddown and lift-off time intervals. Whenever differences in the shape of PSD curves were reflected in SP-4-38-D,[1] an effort was made to revise the measured data prior to scaling to reduce Saturn V holddown and lift-off specifications to the same shape. In a number of cases where the preceding specifications were based on a small number of measurements in a zone, these measurements were reexamined and specifications revised to reflect trends consistent with the adjacent or similar zones.

The specifications must provide a safe level with a low probability that this level may be exceeded by the actual environment. They must contain an allowance for the variation of vibration levels within the zone and for the input dispersion from launch to launch. The main effort was directed toward the establishment of a safe overall rms acceleration level without undue penalty to the test items. The use of the superimposed narrow-band sweep fulfills the requirements to cover local protruding resonance peaks of actual response power spectra with only a small increase in the overall rms acceleration. To cover uncertainties related to scaling and changes in the structural configuration, the frequency range of the superimposed sweep was specified to cover the entire frequency range of these specifications.

APPENDIX D

ACOUSTIC AND VIBRATION

QUALIFICATION TEST REQUIREMENTS AND PROCEDURES

D.1 SCOPE

These specifications provide test requirements and procedures for the testing of GSE assemblies and equipment packages intended for installation on LC-39 and required to support a launch of the Space Shuttle Vehicle.

The actual launch environment is very complex. Practical considerations of simulation require reduction of this environment to a simplified generalized form that can be reproduced and repeated with reasonable accuracy. Therefore, the requirements for test tolerances contain wide margins correlative with the generalization of launch environment specifications and intended to reduce the effort of test setup and equalization.

The intent of these specifications is to provide test requirements that will assure qualification of GSE for service use and will allow the installation of tested specimens on LC-39 without undue concern for the effects related to cumulative damage from preceding testing. This concern is reflected in the requirements for test durations and the monitoring of test specimen functional performance, and in the provisions for additional instrumentation to record the response of the specimen during testing.

D.2 TESTING REQUIREMENTS

GSE required to undergo acoustic and/or vibration qualification testing shall be tested according to the requirements of table D-1, at input levels specified in Appendices A and B.

Vibration testing shall always be performed for qualification. Whenever the antivibration mounting is used, the vibration transmitted to equipment through the mounts may be substantially attenuated and the acoustic input may become the primary source of equipment response. In such cases both vibration and acoustic testing shall be performed.

In cases where past experience clearly shows that equipment is not susceptible to direct acoustic input, acoustic tests may be omitted. The decision to omit acoustic testing must be made in concurrence with the originating agency of the Directorate of Design Engineering, NASA-KSC.

The appropriate equipment operation requirements defined in table D-1 will be specified by the organization responsible for the design of tested equipment and in concurrence with the originating agency of the Directorate of Design Engineering, NASA-KSC.

Table D-1. Equipment Qualification Testing Requirements

Equipment Operation Requirements	Applicable Test Level Specification	Number of Required Tests, Mode of Equipment Operation, Test Duration	
		Acoustic Testing	Vibration Testing
Equipment is operational during all stages of a launch	Lift-off peak	Single Test. Operational mode. 3 min	One test per axis. Operational mode. 3 min/axis
Equipment is operational during Orbiter holddown and lift-off steady state until umbilical disconnect	A. Lift-off steady state until umbilical disconnect B. Lift-off peak	Two tests. A. Operational mode, 3 min B. Nonoperational mode, 3 min	Two tests per axis A. Operational mode, 3 min/axis B. Nonoperational mode, 3 min/axis
Equipment is operational during Orbiter holddown only	A. Orbiter holddown B. Lift-off peak	Two tests. A. Operational mode, 3 min B. Nonoperational mode, 3 min	Two tests per axis. A. Operational mode, 3 min/axis B. Nonoperational mode, 3 min/axis
Equipment remains nonoperational during a launch	Lift-off peak	Single test. Nonoperational mode, 3 min	One test per axis. Nonoperational mode, 3 min/axis

D.3 ACOUSTIC TESTING

D.3.1 GENERAL REQUIREMENTS. The acoustic test is intended to determine the effects of launch acoustics on susceptible GSE and to qualify such equipment for service use. Susceptible equipment is that having low mass-to-area ratio. Typical items are the cabinets and chassis housing electronic equipment and various equipment panels. These items cannot be adequately tested using only vibration input because the vibration response is due mainly to direct acoustic input to the panels and not that transmitted from excitation of supports.

All assemblies requiring acoustic testing will be subjected to either broadband reverberant acoustic field or progressive wave testing. The acoustic random noise waveform will have an approximate normal amplitude distribution. The terms broadband and random include a waveform that may exhibit a multi-line spectrum when analyzed through a system of very narrow band filters. The use of test facilities generating multi-line spectra is acceptable, provided the tolerances of these specifications are met.

Reverberant field testing provides a better approximation of actual launch environment, and it is a preferred way to test complete assemblies. However, the inability of existing reverberant testing facilities to meet specification levels and to accommodate complete assemblies may require progressive wave testing at grazing incidence and on a subassembly (panel) level.

The difficulty in obtaining high intensity random noise environment may justify in some cases the use of discrete frequency excitation. The requirements and specifications for discrete frequency testing are not covered in this document; they will be developed for special cases based on the merits of information that such testing can provide.

D.3.2 REVERBERATION CHAMBER FACILITIES. The test chamber should be of sufficient volume and dimensions to ensure that the insertion of the test specimen will not affect the generation and maintenance of a broadband diffuse field at frequencies above 100 Hz.

Normally, the test specimen will be suspended in the center of the test chamber with soft suspension cords. The suspension system will have a fundamental frequency, in other than the pendulum-type mode, below 25 Hz. A rigid, truss-type fixture that simulates actual assembly installation may be used instead of suspension, provided that it does not impair the generation and maintenance of the specified acoustic field. The fixture will provide elevation of the specimen above the test chamber floor to the same position in which the specimen would be mounted with suspension cords.

At least three microphones, located midway between the test specimen and chamber walls and opposite to three sides of the specimen, will serve as control measurements. The control measurements will be averaged to determine the sound field.

Normally, the shaping of the sound pressure level spectrum will be performed with a dummy specimen in the test chamber. The use of the test specimen in the reverberation chamber when shaping the spectrum is allowed, provided the following conditions are met:

A. The sound pressure level shall be at least 6 dB less than the specification.

B. When the test simulates lift-off peak environment, the total time of trial runs required to shape the spectrum shall not exceed 25 percent of specified test duration.

C. When the test simulates other than lift-off peak environment, the total time of trial runs required to shape the spectrum shall not exceed 50 percent of specified test duration.

Additional microphones will be installed in the proximity of each major surface of the test specimen. The placement of these microphones shall not in any way compromise the test results. The preferable mounting of microphones is by means of a soft suspension from rigid booms extending from the floor, walls, or ceiling of the reverberation chamber or attached to the fixture. Short booms attached to the main frame of the test specimen at points of expected low vibration response may be used, provided the effect of structural vibration on the microphone response will be assessed in the test report. The microphones shall not be attached to light panels of the test specimen.

D.3.3 PROGRESSIVE WAVE FACILITIES. Complete assemblies and subassemblies of panel-mounted equipment may be tested in the progressive wave facilities at grazing incidence, whenever testing in the reverberation chamber cannot be successfully accomplished.

The test specimen will be centrally mounted in the wall of a progressive wave duct. An exponential horn-type duct is preferred to a parallel wall duct. If a parallel wall duct is used, the distance between the walls shall be sufficient to ensure minimum effects on the panel response characteristics through formation of transverse standing waves.

At least three microphones facing the sound source will be used as control measurements and to determine the uniformity of the sound field in the proximity of the duct cross-sectional plane where the test specimen will be mounted. The output of each control microphone will be recorded. The output of the microphone nearest to the test specimen will be used for shaping the specified sound pressure level spectrum. The shaping of the spectrum will be performed without the test specimen in place.

Additional microphones located in the near proximity of the test specimen panel and facing toward the center of the duct will be installed. These microphones will be used to record grazing incidence sound pressure levels to which the test specimen was actually exposed. The number and locations of these microphones shall be specified by the design organization requesting the tests. At least two microphones shall be used and located near the panel edges closest to and farthest from the sound source.

D.3.4 PERFORMANCE OF TEST AND DATA RECORDING. After shaping of the spectrum has been completed and the test specimen installed, the testing will commence.

The calibration scale of all measuring instruments will be recorded prior to turning on any functional components of the test specimen.

The equipment monitoring the functional performance of the test specimen and, when required, the functional components of the test specimen will be turned on.

The overall sound pressure levels will be raised to the specified value and the time count will begin.

The output of control microphones will be recorded at equally spaced time intervals three times during the test:

A. At the beginning of the test, within the first 30 seconds, at least 5 seconds after the overall sound pressure levels have reached test values.

B. In the middle of the test durations.

C. At the end of the test, within the last 30 seconds.

The output of all other measuring instruments will be recorded at least two times during the test, at the same time intervals specified under A. and C. above.

Each recording comprises a sample record. The duration of each recording, the sample record length, shall be at least 15 seconds. At the option of the testing agency, a continuous recording may be made instead of above specification.

The range of flat frequency response of the microphones, within plus or minus 2 dB, shall be from 20 Hz to 8000 Hz.

After completion of the test, and after any functional components of the test specimen are turned off, the calibration scale of all measuring instruments will be recorded again.

Immediately after completion of the test, a visual inspection of the test specimen will be performed, noting any adverse effects the test might have on the tested equipment such as structural failures, cracks, loosening of bolts and connections, broken wires, etc. All findings will be submitted in the test report.

D.3.5 ACOUSTIC TEST TOLERANCES. The test time shall be within plus 10 to 0 percent of the time stated in table D-1.

The overall sound pressure level shall be within plus 2 to minus 2 dB of the specifications.

The individual one-third octave band sound pressure levels shall be within plus 4 to minus 4 dB of the specifications, provided that simultaneous sound pressure levels within the standard one octave bands remain within plus 2 to minus 2 dB of the specifications. Whenever the test specifications are given in terms of one octave band sound pressure levels, the equivalent specifications in terms of one-third octave bands may be obtained by subtracting 4.8 dB from the specification curve at each one-third octave band standard center frequency.

The sound pressure level tolerances apply to the range of frequencies between 100 Hz and 1000 Hz. Outside of this range the capability of the testing facility will be the governing factor.